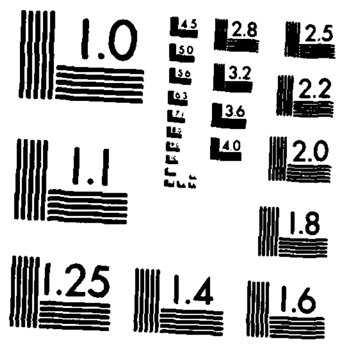
AD-A141 278 STUDY OF POTENTIAL STANDARDIZATION OF DIGITAL FREEZE FRAME VIDEO CODECS(U) DELTA INFORMATION SYSTEMS INC JENKINTOWN PA JAN 84 NCS-TIB-84-3 DCA100-83-C-0047 1/2

UNCLASSIFIED F/G 17/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

3

NCS TIB 84-3

NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN
84-3

STUDY OF POTENTIAL STANDARDIZATION OF DIGITAL FREEZE FRAME VIDEO CODECS

JANUARY 1984

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NCS-TIB-84-3	2. GOVT ACCESSION NO. AD-A141 278	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Study of Potential Standardization of Digital Freeze Frame Video Codecs		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s) DCA100-83-C-0047
9. PERFORMING ORGANIZATION NAME AND ADDRESS Delta Information Systems 310 Cottman Street Jenkintown, PA 19046		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS National Communciations System Attn: NCS-TS Washington, D.C. 20305		12. REPORT DATE January 1984
		13. NUMBER OF PAGES 119
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Freeze Frame, Codecs, Digital Image, Resolution, Video Teleconferencing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of the study was to investigate feasibility of establishing Federal standards for digital Freeze Frame Video Codecs for use in video teleconferencing systems. Its objective was to identify and quantify where feasible those parameters which require standardization in order to achieve interoperability and compatibility in digital Freeze Frame video transmission for teleconferencing systems. The methodology employed in the study included the following key elements: (1) Survey industry to determine who manufactures Freeze Frame codecs. (2) Solicit vendor codec information, study, and analyze Freeze Frame codecs.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Item #20 Cont'd:

>(3) Compare key codec characteristics and parameters; (4) Investigate existing digital Freeze Frame TV systems; and (5) Coordinate with government and other agencies concerned with standardization and interoperability. The scope of this effort involved the solicitation of information provided voluntarily from codec vendors. It did not include the testing of Freeze Frame codecs or teleconferencing systems. Further, the establishment of standards for the parameters of Freeze Frame codecs was not part of this study.

NCS TECHNICAL INFORMATION BULLETIN 84-3

STUDY OF POTENTIAL
STANDARDIZATION OF DIGITAL
FREEZE FRAME VIDEO CODECS

JANUARY 1984

PROJECT OFFICER

Dennis Bodson

DENNIS BODSON
Senior Electronics Engineer
Office of NCS Technology
and Standards

APPROVED FOR PUBLICATION:

Marshall L. Cain

MARSHALL L. CAIN
Assistant Manager
Office of NCS Technology
and Standards

FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronic Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of video teleconferencing standards. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

Office of the Manager
National Communications System
ATTN: NCS-TS
Washington, DC 20305
(202) 692-2124

DELTA INFORMATION SYSTEMS, INC.
310 COTTMAN STREET JENKINTOWN, PA 19046
(215) 572-5640

DIS 84-04

STUDY OF POTENTIAL STANDARDIZATION OF DIGITAL FREEZE FRAME VIDEO CODECS

-FINAL REPORT-

JANUARY 1984

SUBMITTED TO:

NATIONAL COMMUNICATIONS SYSTEM
OFFICE OF TECHNOLOGY AND STANDARDS
ARLINGTON, VA 22204

Contracting Agency:
DEFENSE COMMUNICATIONS AGENCY
Contract Number
DCA100-83-C-0047

Submitted by:

DELTA INFORMATION SYSTEMS, INC.
310 Cottman Street
Jenkintown, Pa. 19046

TABLE OF CONTENTS

PAGE

APPENDICES

LIST OF TABLES

LIST OF FIGURES

SECTION 1.0

INTRODUCTION

1.0 Introduction

This report summarizes the work on Task 4.0, "Study of Potential Standardization of Digital Freeze Frame Video Codecs", performed by Delta Information Systems, Inc. for the Office of Technology and Standards of the National Communications System, an organization of the U.S. Government, under contract number DCA100-83-C-0047. The Office of Technology and Standards, headed by National Communications System Assistant Manager Marshall L. Cain, is responsible for the management of the Federal Telecommu⁻ications Standards Program, which develops telecommunications standards whose use is mandatory by all Federal agencies.

1.1 Definition of the Study

1.1.1 Purpose

The purpose of the sutdy was to investigate feasibility of establishing Federal standards for digital Freeze Frame Video Codecs for use in video teleconferencing systems.

1.1.2 Objective

The objective of the sutdy was to identify and quantify where feasible those parameters which require standardization in order to achieve interoperability and compatibility in digital Freeze Frame video transmission for teleconferencing systems.

1.1.3 Methodology

The methodology employed in the study included the following key elements.

1. Survey industry to determine who manufactures Freeze Frame codecs.

2. Solicit vendor codec information, study, and analyze Freeze Frame codecs.
3. Compare key codec characteristics and parameters.
4. Investigate existing digital Freeze Frame TV systems.
5. Coordinate with government and other agencies concerned with standardization and interoperability.

1.1.4 Scope of the Study

The scope of this study involves the solicitation of information provided voluntarily from codec vendors.

The scope did not include the testing of Freeze Frame codecs or teleconferencing systems. Further, the establishment of standards for the parameters of Freeze Frame codecs was not part of the scope of this initial study.

Future efforts necessary to establish proposed standards for Freeze Frame codecs are discussed in Section 6.0 of this Final Report.

1.1.5 Limitations of the Final Report

Several limitations were imposed upon the study due to time and funding. It is important to understand these factors in reading and accessing the Final Report.

1. The effort was strictly limited to studying only Freeze Frame digital TV codecs even though there are usually many other systems used in a teleconferencing system such as motion codecs, facsimile, audio, and computer graphics. Thus, the Freeze Frame codecs were analyzed for their ability to stand alone.

2. All data used in the various comparison tables and figures were furnished by each codec vendor. DIS neither agrees or disagrees with these data but presents the data in the formats for comparison purposes. However, conclusions and recommendations are made in some of the codec performance and specification parameters.

1.2 Types of Digital Video Teleconferencing

There are in general two types of digital video teleconferencing codecs and systems in use today. The first type of digital video codec involves the transmission of only a single frame or single image of television picture. Usually, in this type of video conferencing, commonly known as freeze frame, and sometimes as still frame, or slow scan TV, one of the 30 TV frames per second generated by the TV camera is "frozen" or "stored" in a digital memory in 1/30 second.

The stored image can be processed or compressed to reduce transmission time and then transmitted over various narrowband data or telephone circuits. It is apparent then that "motion" is not conveyed with a Freeze Frame video codec since a single frame is transmitted rather than a sequence of frames which are necessary to depict motion information. However each frame can contain substantial amounts of unformatted visual information and therefore fulfills an important function in the family of video transmission system.

The second type of digital video codec involves the trans-

mission of real time sequences of TV frames or images in a manner which conveys motion. In some motion codecs, the third dimension of time is utilized in conjunction with the other intraframe dimensions of television signals for processing and compressing the image sequences to minimize transmission data rates.

The Freeze Frame codec process is discussed in the remainder of this report. Motion digital codecs are not analyzed in the report.

1.3 Summary of the Report

Section 2.0 provides a brief outline of some current efforts in the standardization process for Freeze Frame codec technology. A description of vendor and market analysis of Freeze Frame codecs is presented in Section 3.0.

The comparison of the Freeze Frame codecs is provided in Section 4.0 for various codec parameter and performance criteria including resolution, TV test signals, data formats, and bit error rate performance.

In Section 5.0 key parameters are identified for consideration in the possible development of Freeze Frame codec standards. Section 6.0 delineates several steps and processes which may be required in order to develop a standard which provides for interoperability of Freeze Frame codecs. Finally, a number of appendices are provided for further in-depth consideration of Freeze Frame codecs.

SECTION 2.0

FREEZE FRAME CODEC

STANDARDIZATION EFFORTS

2.0 Freeze Frame Codec Standardization Efforts

This section provides a brief outline of some of the efforts being expended by standards organizations in the study and development of standards for digital television systems and equipments. It appears that most of the effort is related to the implementation of the digital TV studio of the future. Some of the efforts involve the conversion of color analog TV signals to digital format, decoding of composit color signals into components, control of digital TV equipments, distribution of digital TV signals within the studio, and digital video tape recorders. Nearly all efforts are aimed at the generation, processing and transmission of broadcast or professional quality television.

No formal standards are known to have been adopted expressively for application to video teleconferencing systems and codecs. Perhaps, one reason for this lack of standardization efforts in video teleconferencing systems/equipments is that the technology needed to support and develop with acceptable performance is still rapidly growing while cost effective satellite communications needed for video teleconferencing has just recently become readily available. The CCITT (Study Group XV) is now studying several recommendations aimed at video teleconferencing systems, primarily for motion codecs.

This Freeze Frame study represents one of the initial attempts to begin the standardization process for Freeze Frame codecs for video teleconferencing. The following subsections provide insight into some of the activities of standards organizations in the areas of digital TV.

2.1 International Radio Consulting Committee (CCIR)

The CCIR is an international standards organization which develops standards relating to international television communications. CCIR had recently adopted Recommendation AA-11 which defines standards for the component coding of color television signals. The standard is commonly known as the 4.2.2 sampling hierarchy because the luminance signal (Y) is sampled at twice the frequency of the two color difference signals (R-Y, B-Y). In the standard adopted, the luminance signal is sampled at 13.5 MHZ and the chrominance signals at 6.75 MHZ.

An important international feature of the standard is that there are the same number of pixels (samples) per digital active TV line for both 525 line and 625 line television systems (720 for luminance and 360 for chrominance).

One of the current CCIR activities is addressing specifications for a digital control protocol to be used in the digital studio.

2.2 Society of Motion Picture and Television Engineers (SMPTE)

SMPTE is perhaps the most active standards organization working on Digital Television standards in the United States. Its working group on Digital Video Standards in coordination with other international groups helped to develop the component digital coding standard described above. Some of its current efforts as reported by SMPTE are listed below.

1. Television Video Committee

   A subgroup is working to develop a standard for the digital control of TV equipments.

2. Video Recording and Reproduction Technology Committee

A working group is developing standards for component analog video 525/60 TV signals which is to be coordinated with other digital video standards.

3. New Technology Committee

The Digital Video Standards working group has developed a digital studio interface. The Digital Television study group is addressing the problems of common carrier transmission in the mixed analog/digital environment and also studying the different digital hierarchical transmission rates in different regions of the world. A subgroup on Digital Studio Implementation is studying the transition from analog equipment to component - coded digital equipment in television production, post-production, and broadcasting.

Another study group on Digital Television Tape Recording is investigating the preferred characteristics of a digital videotape recorder.

A study group on High Definition Television is working toward a single world-wide standard for a HDTV system.

2.3 International Telegraph and Telephone Consultative Committee (CCITT)

Study Group XV and its Working Party on Visual Telephony is considering several draft recommendations pertaining to digital video teleconferencing. A draft recommendation on a frame structure for digital transmission of motion video conference signals at 2048 KBS has been approved by the study group.

A preliminary draft for a codec standard at 2048 KBS is being considered by the Working Party as a framework for a future recommendation. Initial contributions on Still-Picture Transmission (Freeze Frame) concerning experiments relating to assessment of picture quality have been submitted by Italy. No submission have been made on Freeze Frame codec equipments to the CCITT through December 31, 1983.

2.4 Joint Committee on Intersociety Coordination (JCIC)

This organization was formed in the 1950's to coordinate television standards activities. The current members of the JCIC are the following organizations.

SMPTE- Society of Motion Picture Television Engineers

EIA- Electronic Industries Association

IEEE- Institute of Electrical Electronics Engineers

NAB- National Association of Broadcasters

NCTA- National Cable Television Association

Current efforts involve coordinating activity toward the standardization of advanced television systems. Digital TV standardization efforts are also coordinated within the JCIC.

SECTION 3.0

VENDOR AND MARKET ANALYSIS

3.0 Vendor and Market Analysis

3.1 Approach

The purpose of this task was to obtain technical information about all known freeze frame codecs. Initially, a letter was sent to organizations and vendors who had indicated an interest in fabricating freeze frame codecs. A detailed technical questionnaire and a subsequent supplemental questionnaire were then sent to those vendors who indicated that they were manufacturing and/or developing freeze frame codecs. The remainder of Section 3.0 describes the information obtained from these efforts.

3.2 Codec Vendor Questionnaire

The initial questionnaire constructed to obtain information from the freeze frame codec vendors was composed of 5 parts as follows:

Part 1. Product Nomenclature and General Description

Part 2. Technical Specifications - Input and Output Signals

Part 3. Technical Specifications - Performance

Part 4. Physical Description and Specifications

Part 5. Other Product Data

A supplemental questionnaire was also sent to each vendor requesting more detailed data about the time required to transmit an image at the data rates for which the equipment was designed and to further detail equipment options and optional features. These details are essential for determining the feasibility of

establishing a possible codec transmission standard.

The instructions provided to each vendor indicated that the response to the questionnaire would be used to compare codecs and "that only approved and non-proprietary information and data will be used in the study."

Appendix A contains the letter and instructions sent to each codec vendor. Also,in Appendix B is an outline of the initial freeze frame questionnaire provided to the vendors involved in codec development. The following sections provide a brief description of the codec information which was solicited from the vendors; the vendor responses are compiled in corresponding tables.

3.2.1 Part 1. Product Nomenclature and General Description

The purpose of Part 1 was to obtain information about the vendor including point of contact , address, and location. Secondly, specific data about the codec itself was requested including the codec name, model, data introduced, number of units installed and locations.

Next, pricing information was solicited on the basic unit, options, maintenance, spares, and training. Questions concerning the product life were asked including expected product life period, anticipated improvements or modifications, growth potential and any other comments or information on product life.

Details about warrantees and services were solicited. Particularly, questions on maintenance, repairs, spares, and training were asked. The questions and responses are shown in Tables 3-1 and 3-2. In these tables, references are made to several addenda which contain supplemental data or answers to questions. These

Table 3-1

PRODUCT NOMENCLATURE AND GENERAL DESCRIPTION PARTS 1 AND 2

1.VENDOR IDENTIFICATION								
A. COMPANY NAME	COLORADO VIDEO, INC.	NEC AMERICA INC., BROADCAST EQUIPMENT DIVISION	ROBOT RESEARCH, INC	MARCOM	INTERAND CORPORATION	G.E.C. JERROLD LIMITED	GRINNELL SYSTEMS	E-SYSTEMS, INC.
B. STREET ADDRESS	3245 PRAIRE AVENUE	130 MARTIN LANE	7391 CONVOY COURT	P.O.BOX 66507	666 N. LAKE SHORE DRIVE	642-643 AJAX AVENUE	6410 VIA DEL ORO DRIVE	P.O.BOX 226118
C. CITY,STATE,ZIP	BOULDER, COLORADO 80301	ELK GROVE VILLAGE, ILLINOIS. 60007	SAN DIEGO, CA. 92111	SCOTTS VALLEY, CA 95066	CHICAGO, ILLINOIS 60611	SLOUGH,SL14BG ENGLAND	SAN JOSE, CA 95131	DALLAS, TEXAS. 75266
D. POINTS OF CONTACT, TITLES, AND TELEPHONE NUMBERS	GLEN SOUTHWORTH PRESIDENT (303) 444-3972 JOHN SPARKS SENIOR ENGINEER (303) 444-3972	R.DENNIS FRASER VICE PRESIDENT-GENERAL MANAGER NEC AMERICA, INC (312) 640-3792	LARRY D. HALLER SALES MANAGER, COMMERCIAL PRODUCTS (619) 279-9430	MARTIN JACKSON PRESIDENT (408) 438-4723	LEONARD REIFFEL CHIEF EXECUTIVE OFFICER (312) 943-1200 GEOFFREY DUNBAR CHIEF OPERATING OFFICER (312) 943-1200	JENNISON GREY (0753) 821671	M.MICHAEL STROZZA VICE PRESIDENT,MARKETING (408) 629-9191 JIM HIXSON MARKETING MANAGER (408) 629-9191	J.G.CARR MGR. INFORMATION SYSTEMS (214) 272-0515, EXT.3294 W.M.GRISSOM RMDS PROGRAM MANAGER (214) 272-0515, EXT.3118
2.CODEC IDENTIFICATION								
A. CODEC NAME	DIGITAL SLOW-SCAN TRANSCEIVER	TELEPHONE VIDEO SYSTEM	MODEL 600 SERIES	TELEPIX	DISCON 1000 (A SYSTEM, NOT A CODEC)	SLOW SCAN II	GMP	N/A
B. MODEL NUMBER (S)	285	TVS-703	601,603,606,608,612,617, 630,635,635F-13	TO BE DETERMINED			27 671	N/A
C. DATE INTRODUCED	1979	NOVEMBER, 1981	1979	PROTOTYPE,SEPTEMBER 1983 TCA SHOW, SAN DIEGO, CA.	1983	PROTOTYPE UNITS ONLY	1979	N/A
D. SPECIFICATION ENCLOSED	YES	YES	YES	YES	NO	N/A	NO	N/A
E. APPLICATION NOTES ARE PROVIDED	NO	NO	YES	NO	NO	N/A	NO	N/A
F. NUMBER OF UNITS INSTALLED	70	APPROXIMATELY 300	SEE ADDENDUM RRI-1	NONE	PROPRIETARY	N/A	14	N/A
G. USERS,LOCATIONS,POINTS OF CONTACT	SEE ADDENDUM CVI-1	SEE ADDENDUM NEC-1	SEE ADDENDUM RRI-1	NONE	CONTACT INTERAND	N/A	E-SYSTEMS, RAPICOM	N/A
H. OTHER IDENTIFICATION INFORMATION	N/A	N/A	N/A	NONE	N/A	N/A	N/A	N/A
3.PRICING								
A. PUBLISHED SALE PRICES	YES	YES	YES	NO	N/A	N/A	NO	N/A
B. PRICE SHEET INCLUDED	YES	SEE ADDENDUM NEC-2	YES	NO	N/A	N/A	NO	N/A
C. DATE OF PRICE SHEET	JULY 1983	JUNE 21, 1982	MAY 16, 1983	N/A	N/A	N/A	N/A	N/A
D. PRICE SHEET INCLUDES ALL CODEC CONFIGURATIONS	YES	YES	NO	NO	N/A	N/A	NO	N/A
E. INCLUDES OPTION PRICES	YES	YES	NO	NO	N/A	N/A	N/A	N/A
F. INCLUDES MAINTENANCE, REPAIR AND SPARES PRICING	NO	$50.00 PER HOUR	NO	NO	N/A	N/A	N/A	N/A
G. INCLUDES TRAINING COST	NO	$400 PER DAY EXCLUDING TRAVEL	NO	NO	N/A	N/A	N/A	N/A
H. PLEASE INCLUDE ANY OTHER PRICING INFORMATION	N/A	N/A	15KHZ BANDWIDTH OPTION. SENDS 256 X 256 IN 8.5 SEC. PRICE: $400.00	APPROXIMATELY $7,000	PRICING IS BY SYSTEM AND CAN INCLUDE A WIDE RANGE OF MODULES / COMPONENTS	N/A	BY QUOTATION	N/A
4.PRODUCT LIFE								
A. EXPECTED PRODUCT LIFE PERIOD	3 YEARS	THREE (3) TO FOUR (4) YEARS	THROUGH 1985	FIVE YEARS	UPDATES WILL BE COMPATIBLE.	N/A	1985	N/A
B. ARE IMPROVEMENTS/MODIFI-CATIONS PLANNED? IF YES, PLEASE PROVIDE DETAILS.	YES: MICROCOMPUTER CONTROL FOR DATA COMPRESSION, PROTOCOL CONVERSION, IMAGE MANIPULATION	YES: NEW PERIPHERAL CONTROL SYSTEM WILL BE ADDED AS AN OPTION	NO	YES: LIGHT PEN INTER- ACTIVE GRAPHICS	YES: PROPRIETARY	1;NTSC 525 LINE,60 HZ 2;PAL AND NTSC COMPOSITE CODEC	YES	N/A
C. GROWTH POTENTIAL	N/A	N/A	N/A	$1.5 M/YEAR	MAJOR	N/A	2-BITS TO 4-BITS	N/A
D. DO YOU PROVIDE CUSTOM CONFIGURATIONS?	YES	AS REQUIRED	YES: SEE ADDENDUM RRI-2.	YES	YES	N/A	YES	N/A
E. PLEASE INCLUDE ANY ADDIT-IONAL COMMENTS/INFORMATION ON PRODUCT LIFE.	THE 285 HAS AN OPTIONAL PARA- LLEL DIGITAL (DMA) I/O PORT THAT CAN BE USED TO PROVIDE ADDITIONAL STORAGE,PROCESSING, AND CONTROL. SEE MODEL 723.	N/A	THIS MODEL WILL BEGIN TO BE REPLACED BY A NEW SERIES WITHIN THE NEXT 12 MONTHS.	PLAN TO SELL IN A SYSTEM AS WELL FOR APPROX. $15,000 (MODEL 540)			N/A	N/A

Table 3-2

WARRANTIES AND SERVICES.

COMPANY NAME	COLORADO VIDEO, INC.	NEC AMERICA INC.	ROBOT RESEARCH, INC.	MARCOM	INTERAND CORPORATION	G.E.C. JERROLD LIMITED	GRINNELL SYSTEMS	E-SYSTEMS, INC.
5. WARRANTEES								
A. OVERVIEW/DESCRIPTION OF YOUR POLICY.	MATERIAL AND WORKMANSHIP: ONE YEAR.	SEE ADDENDUM NEC-3.	WE GUARANTEE ALL PARTS AND LABOR FOR 1 YEAR AFTER SALE.	90 DAY	YES, 90 DAYS PARTS/LABOR.		1 YEAR PARTS AND LABOR- FACTORY SERVICE ONLY	N/A
B. WRITTEN POLICY PROVIDED.	YES	YES	YES	NO	YES	N/A	YES	N/A
C. EXTENDED PERIODS AVAILABLE. PLEASE DESCRIBE.	NO	3 MONTH LABOR AND 6 MONTH PARTS.	YES; WE WILL NEGOTIATE EXTENDED WARRANTY PERIODS THOUGH TO DATE NONE HAVE BEEN NEGOTIATED.	NO	YES	N/A	YES	N/A
6. SERVICE, MAINTENANCE, REPAIRS, SPARES, TRAINING.								
A. CUSTOMER FIELD SERVICE PROVIDED.	YES	YES	YES	N/A	YES	N/A	YES	N/A
B. VENDOR EMPLOYEE OR CONTACT.	RICHARD KILLEBREW	VENDOR EMPLOYEE	INSTALLING DEALER WILL PROVIDE FIELD SERVICE.	N/A	T.T. TUTT	N/A		N/A
C. RESPONSE TIME (WRITTEN).	AS MANPOWER IS AVAILABLE	IMMEDIATE	AS ARRANGED WITH INSTALLING DEALER.	N/A	48 HOURS	N/A	N/A	N/A
D. CUSTOMER REPAIRS PROVIDED.	YES	YES	NO	N/A	YES	N/A	YES	N/A
E. CARD AND UNIT LEVEL.	YES	REPAIR AND SERVICE LOAN PROVIDED TO CARD OR UNIT .	N/A	N/A	YES	N/A	YES	N/A
F. FACTORY LOCATION.	BOULDER, COLORADO	TOKYO, JAPAN.	ALL WARRANTY WORK AND VIRTUALLY ALL REPAIRS ARE DONE AT THE FACTORY.	N/A	CHICAGO	N/A	SAN JOSE, CA.	N/A
G. FIELD DEPOTS.	NONE	NEC AMERICA, INC. ELK GROVE VILLAGE, IL.	NONE	N/A	CHICAGO, DETROIT . (5 MORE IN PROCESS)	N/A	NONE	N/A
H. RESPONSE TIME.	24 HOURS	IMMEDIATE TO THREE DAYS.	TYPICALLY WITHIN 5 DAYS AFTER RECEIPT OF FAULTY EQUIPMENT.	N/A	48 HOURS TYPICAL.	N/A	2 WEEKS FOR BOARD REPAIRS	N/A
I. SPARES LISTING INCLUDED.	YES	NO	NO	N/A	YES	N/A	YES	N/A
J. RECOMMENDED SPARES LISTING INCLUDED.	N/A	NO	NO	N/A	YES	N/A	YES	N/A
K. CUSTOMER TRAINING COURSE PROVIDED.	YES; BY REQUEST.	YES	NO	N/A	YES	N/A	YES	N/A
L. FACTORY OR CUSTOMER LOCATION.	EITHER	BOTH	N/A	N/A	EITHER	N/A	EITHER	N/A
M. TYPE OF TRAINING COURSE USER, OPERATOR, MAINTENANCE.	AS REQUIRED	USER, OPERATOR, MAINTENANCE.	N/A	N/A	ALL	N/A	MAINTENANCE	N/A
N. DURATION OF COURSE.	AS REQUIRED	VARIABLE (1-3 DAYS)	N/A	N/A	1/2 TO 2 DAYS		3 DAYS	N/A
O. CUSTOMER TRAINING MANUALS PROVIDED.	NO	YES	NO	N/A	YES	N/A	YES	N/A
P. PLEASE INCLUDE ANY OTHER DATA RELATING TO THE ABOVE ITEMS.			SEE ADDENDUM RRI-3.	N/A	N/A	N/A	BOARD-SWAP AVAILABLE BY AGREEMENT. SERVICE VISITS ARE AS AVAILABLE	N/A

addenda are contained in Appendix C of this report.

3.2.2 Part 2. Technical Specifications - Input and Output Signals

Data about the input and output codec signals was requested in Part 2. Characteristics of the input and output video signals were to be supplied including standards, synchronization levels, and impedances. Details were requested about the codec digital output signals including bit rates and formats.

Information was asked about other digital data ports to the codec and their signal characteristics. The questions and responses are shown in Tables 3-3 and 3-4.

3.2.3 Part 3. Technical Specifications - Performance

This section of the questionnaire contains pertinent questions. about the codec specifications and its stated performance. Parameters such as number of pixels, sampling rates, precision of encoding and frequency response were asked. Performance data as measured in terms of the more usual analog measurements including differential gain and phase, signal-to-noise ratio, and luminance-chrominance gain and delay inequalities was to be supplied.

The codec performance for various data link error conditions ranging from a bit error rate of 10^{-6} to 10^{-3} was solicited.

Specific questions were asked about the compression techniques employed in the codec. The general type of compression algorithm was to be listed. Compression ratios, descriptions, and growth potential were also to be contained in the response.

Table 3-3

VIDEO INPUT/OUTPUT SIGNALS.

COMPANY NAME	COLORADO VIDEO, INC.	NEC AMERICA INC.	ROBOT RESEARCH, INC.	MARCOM	INTERAND CORPORATION	G.E.C. JERROLD LIMITED	GRINNEL SYSTEMS	E.SYSTEMS, INC.
1. VIDEO INPUT SIGNALS								
A. DESCRIBE VIDEO INPUT SIGNAL REQUIREMENTS/LIMITATIONS. WHAT STANDARDS? (I.E. RS-170, RS-170 A)	RS-170 (MONOCHROME) NTSC (COLOR)	RS-170 OR NTSC.	RS 170 COMPOSITE MONOCHROME, CCIR COMPOSITE MONOCHROME.	RS-170	RGB AND SYNC PER RS-170.	CCIR SYSTEM I 625 LINE 50 HZ FIELD RATE MONOCHROME AND COLOUR IN COMPONENTS (RGB OR YUV). NON-INT.1250 LINE 50 HZ AVAILABLE AS OPTION.	N/A	RS-170
B. COLOR/MONOCHROME OR BOTH.	BOTH	BOTH	MONOCHROME	BOTH	BOTH	BOTH	N/A	MONOCHROME
C. NUMBER OF VIDEO INPUTS.	3	FIVE (5)	1	1	EXPANDABLE TO 8.	6 MONOCHROME OR 2 COLOR INDIVIDUALLY SWITCHABLE.	N/A	ONE (1)
D. SIGNAL VOLTAGES AND IMPEDANCES.	1 V P-P; 75 OHMS.	COMPOSITE 1 VP-P, 75 OHMS.	1.0 V P-P WHITE POSITIVE INTO 75 OHMS. 100 OHMS.	1 V P-P AT 75 OHMS.	1 V P-P, 75 OHMS.	0.7V P-P VIDEO WITH 0.3 V SYNC ON GREEN, Y, MONO 75 OHMS	N/A	ONE (1) VOLT PEAK TO PEAK AT 75 OHMS
E. BALANCED/UNBALANCED.	UNBALANCED	UNBALANCED	UNBALANCED	UNBALANCED	PER RS-170	UNBALANCED	N/A	UNBALANCED
F. REQUIRES SYNC INPUT.	GENLOCKS TO INCOMING VIDEO.	NO	NO	NO	YES	NO	N/A	YES
G. DESCRIPTION OF SYNC INPUT (COMPOSITE, VERTICAL, HORIZONTAL, VOLTAGE LEVELS, ETC)	COMPOSITE	N/A	AS AN OPTION CAN ACCEPT SERRATED COMPOSITE SYNC.	MAY BE GENLOCKED TO COMPOSITE.	COMPOSITE, 4 V P-P.	COMPOSITE VIDEO WITH 0.3V SYNC.	N/A	COMPOSITE
H. VIDEO TEST SIGNAL INPUT PROVIDED.	NO	YES	NO	NO	INTERNALLY GENERATED.	N/A	N/A	NO
I. ANY RESTRICTIONS ON VIDEO INPUT.	NO	NO	NONE WITHIN RS 170.	NO	RS-170	N/A	N/A	NO
J. ANY OTHER INPUT CHARACTERISTICS.	N/A	N/A	N/A	NONE	N/A	N/A	N/A	NONE
2. VIDEO OUTPUT SIGNALS								
A. DESCRIBE VIDEO OUTPUT SIGNAL STANDARDS. (RS-170, RS-170A, ETC.)	NTSC COMPATIBLE (COLOR), RS-170 (MONOCHROME).	NTSC TYPE	RS-170 NON-INTERLACED, 60 FIELDS PER SECOND.	RS-170	RGB AND SYNC	2 LUMINANCE OUTPUTS(MONO, GREEN, OR Y).2 CHROMA(RED AND BLUE OR U AND V).	RS-343	RS-170
B. COLOR/MONOCHROME OR BOTH	BOTH	BOTH	MONOCHROME	BOTH	BOTH	BOTH	MONOCHROME	MONOCHROME, COMPOSITE.
C. NUMBER OF VIDEO OUTPUTS. IS THE VIDEO OUT A COMPOSITE VIDEO SIGNAL?	ONE, COMPOSITE.	TWO (2) OUTPUTS, COMPOSITE.	1 COMPOSITE VIDEO OUTPUT.	1, YES	1 SET	SEE ABOVE. COMPOSITE	COMPOSITE	FOUR (MAXIMUM)
D. SIGNAL VOLTAGE AND IMPEDANCE.	1 V P-P; 75 OHMS.	1 V P-P, 75 OHMS.	1.4 V P-P WHITE POSITIVE INTO 75 OHMS.	1 V P-P AT 75 OHMS.	750 MV, 75 OHM.	LUMINANCE 0.7 V P-P WITH 0.3V SYNC. CHROMINANCE 0.7VP-P. 75 OHMS.	1.0 V P-P, 75 OHMS	ONE (1) VOLT PEAK-TO-PEAK AT 75 OHMS.
E. BALANCED/UNBALANCED.	UNBALANCED	UNBALANCED	UNBALANCED	UNBALANCED	UNBALANCED	UNBALANCED	UNBALANCED	UNBALANCED
F. PROVIDE SYNC OUTPUT?	NO	NO	NO	YES	YES	NO	YES	YES
G. DESCRIPTION OF SYNC OUTPUT SIGNAL (COMPOSITE, VERTICAL, HORIZONTAL, VOLTAGE LEVELS).	N/A	N/A	N/A	COMPOSITE	4 V P-P PER RS-170.	COMPOSITE VIDEO	ALL	COMPOSITE
H. VIDEO TEST OUTPUT PROVIDED.	NO	YES	NO	NO	YES	N/A	NO	NO
I. ANY OTHER OUTPUT CHARACTERISTICS.	N/A	N/A	N/A	NONE	N/A	N/A	1024 X 786 OR 768 X 1024.	N/A

Table 3-4 DIGITAL INPUT/OUTPUT SIGNALS.

A. COMPANY NAME	COLORADO VIDEO, INC.	NEC AMERICA INC.,	ROBOT RESEARCH, INC	MARCOM	INTERAND CORPORATION	G.E.C. JERROLD LIMITED	GRINNELL SYSTEMS	E-SYSTEMS, INC.
3. DIGITAL OUTPUT AND INPUT SIGNALS A. DESCRIPTION/TYPE OF OUTPUT SIGNALS (BIT RATE, DATA LINK, ETC.).	SERIAL BINARY NRZ, RS-232C, OR MIL STD 188C.	EIA STANDARD RS-232 OR CCIR RECOMMENDATION V.24, V.35.	SEE ADDENDUM RRI-3. NOT APPLICABLE	V.24 TO 19.2 KB, V.35 TO 500 KB.	RS-232, 9600 BITS/SEC.	UP TO 64 KB/S, INTERFACES WITH X21 LEASED LINES.	N/A	MIL-STD-188C AT 2400 BPS
B. DESCRIBE OUTPUT FORMAT (PROTOCOL)	BINARY PCM; FOUR LOWEST CODES USED TO PROVIDE FRAME, LINE, AND WORD SYNC, AND RECEIVER RESET.	NON-STANDARD (PROPIETARY).	NOT APPLICABLE	PROPIETARY	SPECIAL	BASED ON X-25 PACKET, BUT WITH EXTENDED SEQUENCE TO ALLOW FOR LONG LOOP DELAY IN HIGH BER NETWORK.	N/A	E-SYSTEMS
C. NUMBER OF DIGITAL OUTPUTS, NUMBER OF DIGITAL INPUTS.	ONE ONE	ONE (1) ONE (1)	NOT APPLICABLE NOT APPLICABLE	2 2	1 1	N/A N/A	N/A N/A	N/A N/A
D. OUTPUT BIT RATE; LIST ALL RATES AND RANGES; LIST ALL RESTRICTIONS/ CONDITIONS.	0-500 K BITS/SEC (MONOCHROME). 0-200 K BITS/SEC (COLOR).	MODEM DEPENDENT, UP TO 1.544 M BITS/SEC.	NOT APPLICABLE NOT APPLICABLE NOT APPLICABLE	TO 500 KB. 4.8 KB TO 500 KB. NONE	9600 BITS/SEC. 4800, 7200, 9600 BITS/SEC.	64 KB/S.	N/A N/A N/A	2400 BPS
E. SYNCHRONOUS/ASYNCHRONOUS	SYNCHRONOUS	SYNCHRONOUS	NOT APPLICABLE	SYNCHRONOUS	SYNCHRONOUS	N/A	N/A	ASYNCHRONOUS
F. EXTERNAL CLOCK	REQUIRED	REQUIRED	NOT APPLICABLE	REQUIRED	SPECIAL CLOCK PROVIDED.		N/A	N/A
G. BIT RATE/CLOCK STABILITY AND ACCURACY.	THE 285 TRACKS THE CLOCK, SO ACCURACY IS NOT CRITICAL.	MODEM DEPENDENT	NOT APPLICABLE	AS PROVIDED BY MODEM.	0.01%	N/A	N/A N/A	N/A

This data is listed in Tables 3-5, 3-6, 3-7.

3.2.4 Part 4. Physical Description and Specifications

This part of the questionnaire was included to obtain information about the physical codec specifications, power requirements, environmental operation, and connector interfaces in order to determine common characteristics among the codecs as well as to point out any unusual features which could possibly affect future standardization efforts. This information is listed in Table 3-8.

3.2.5 Part 5. Other Product Data

The following kinds of data concerning codecs were solicited in this part of the questionnaire. A description of codec status, indicators and alarms, built-in test equipment, and operator controls was to be provided. Additionally, the use of encryption or scrambling functions was to be detailed with its effects upon the transmission protocol.

Copies of manuals, product documentation, brochures, and technical notes were requested from all vendors. A summary of the vendor responses is listed in Table 3-9.

Table 3-5 VIDEO PERFORMANCE.

COMPANY NAME	COLORADO VIDEO, INC.	NEC AMERICA INC.,	ROBOT RESEARCH, INC	MARCOM	INTERAND CORPORATION	G.E.C.JERROLD LIMITED	GRINNELL SYSTEMS	E-SYSTEMS, INC.
1.VIDEO PERFORMANCE								
A.HORIZONTAL SAMPLING RATE	5.5 MHZ OR 10 MHZ	10.8 MHZ	5 MHZ	10.33 MHZ	12 MHZ	4.5, 9.0, 13.5 MSAMPLES/S	N/A	15.750 KHZ
B.HORIZONTAL PIXELS	256 OR 512	684	256	512	640	MONO;256,512,768 COLOR;LUM-512,CHROM-256.	N/A	512
C.VERTICAL SAMPLING RATE	15,750	N/A	15750 HZ	525	NOT APPLICABLE	N/A	N/A	33.3 MSEC
D.VERTICAL PIXELS	240 OR 480	MODE DEPENDENT;262 OR 525	256	512	484 LINES	MONO;256,512. COLOR;LUM-512,CHROM-256	N/A	480
E.LUMINANCE SAMPLING RATE	SAME AS ABOVE	10,8 MHZ	N/A	COMPOSITE	12 MHZ	4.5,9.0,13.5 MSAMPLES/S	N/A	N/A
F.CHROMINANCE SAMPLING RATE(S)(IF COMPONENT CODING IS USED)	N/A	N/A	N/A	COMPOSITE	3 MHZ	N/A	N/A	N/A
G.NO. OF CHROMINANCE CHANNELS	NONE	N/A	N/A	COMPOSITE	2	COMPOSITE OR RGB OR YUV	N/A	NONE
H.PRECISION OF LUMINANCE ENCODING	6 OR 8 BITS	8 BITS	N/A	8 BITS	3%	8-BITS	N/A	N/A
I.PRECISION OF CHROMINANCE ENCODING	N/A	N/A	N/A	8 BITS	6%	N/A	N/A	N/A
J.VIDEO FREQUENCY RESPONSE	4 MHZ	OPTION DEPENDENT; UP TO 400 TV LINE (H)	2.5 MHZ	4.2 MHZ	2 MHZ	N/A	N/A	5 MHZ
K.LUMINANCE - CHROMINANCE GAIN INEQUALITY	N/A	NONE	N/A	2%	LESS THAN 6%	N/A	N/A	N/A
L.LUMINANCE TO CHROMINANCE DELAY INEQUALITY	N/A	< 100 NS	N/A	2%	LESS THAN 42 NANO-SEC	N/A	N/A	N/A
M.SHORT TIME WAVEFORM DISTORTION	N/A	NONE	N/A	5 NANOSECONDS	N/A	N/A	N/A	UNKNOWN
N.SIGNAL TO QUANTIZING NOISE RATIO	N/A	> 40 DB	36 + 10.5 = 46.5 DB	52 DB	+/- 1/2 LSB	N/A	N/A	UNKNOWN
O.DIFFERENTIAL GAIN	N/A	< 4%	N/A	2%	N/A	N/A	N/A	UNKNOWN
P.DIFFERENTIAL PHASE	N/A	< 2 DEGREES	N/A	2 DEGREES	N/A	N/A	N/A	UNKNOWN
Q.FIELD TIME WAVEFORM DISTORTION	N/A	< 1%	N/A	1%	N/A	N/A	N/A	UNKNOWN
R.LINE TIME WAVEFORM DISTORTION	N/A	< 1%	N/A	1%	N/A	N/A	N/A	UNKNOWN
S.ANY OTHER PERFORMANCE SPECIFICATIONS	N/A	N/A	N/A	NONE	N/A	SEE ADDENDUM GECJ-1	N/A	N/A

Table 3-6 BIT ERROR RATE PERFORMANCE.

COMPANY NAME	COLORADO VIDEO, INC.	NEC AMERICA INC.,	ROBOT RESEARCH, INC	MARCOM	INTERAND CORPORATION	G.E.C.JERROLD LIMITED	GRINNELL SYSTEMS	E-SYSTEMS, INC.
2.BIT RATE PERFORMANCE								
A.CONDITION 1; DATA LINK BIT ERROR RATE IS 10E-6 OR LESS								
1.ARE ERRORS PERCEPTIBLE?	NO QUANTITATIVE DATA ON ERROR RATE PERFORMANCE HAS BEEN TAKEN.	YES	N/A	N/A	NO	SEE ADDENDUM GECJ-2	N/A	N/A
2.DESCRIBE VISUAL EFFECTS OF ERRORS - BLOCKS, LINES, STREAKS, COLOR CHANGES, ETC.	DATA IS PCM SO ERRORS CAUSE DOTS IN PICTURE	HORIZONTAL STREAKS ON LINES	N/A	N/A	ANY ERRORS ARE CORRECTED.	SEE ADDENDUM GECJ-2	N/A	N/A
3.DOES RECEIVER (DECODER) MAINTAIN COMPLETE SYNCHRONIZATION (I.E. VERTICAL, LINE, AUDIO, ETC.)?	N/A	YES	N/A	N/A	YES	SEE ADDENDUM GECJ-2	N/A	N/A
4.IF SCRAMBLING/ENCRYPTION SYSTEM IS SUPPLIED, IS DESCRAMBLING/DECRYPTING AFFECTED?	N/A	N/A	N/A	N/A	NOT SUPPLIED	SEE ADDENDUM GECJ-2	N/A	N/A
B.CONDITION 2; DATA LINK BIT ERROR RATE IS 10E-5 OR LESS								
1.ARE ERRORS PERCEPTIBLE?	N/A	YES	N/A	N/A	NO	SEE ADDENDUM GECJ-2	N/A	N/A
2.DESCRIBE VISUAL EFFECTS OF ERRORS - BLOCKS, LINES, STREAKS, COLOR CHANGES, ETC.	N/A	HORIZONTAL STREAKS ON LINES	N/A	N/A	ANY ERRORS ARE CORRECTED	SEE ADDENDUM GECJ-2	N/A	N/A
3.DOES RECEIVER (DECODER) MAINTAIN COMPLETE SYNCHRONIZATION (I.E. VERTICAL, LINE, AUDIO, ETC.)?	N/A	YES	N/A	N/A	YES	SEE ADDENDUM GECJ-2	N/A	N/A
4.IF SCRAMBLING/ENCRYPTION SYSTEM IS SUPPLIED, IS DESCRAMBLING/DECRYPTING AFFECTED?	N/A	N/A	N/A	N/A	NOT SUPPLIED	SEE ADDENDUM GECJ-2	N/A	N/A
C.CONDITION 3; DATA LINK BIT ERROR RATE IS 10E-4 OR LESS								
1.ARE ERRORS PERCEPTIBLE?	N/A	YES	N/A	N/A	NO	SEE ADDENDUM GECJ-2	N/A	N/A
2.DESCRIBE VISUAL EFFECTS OF ERRORS - BLOCKS, LINES, STREAKS, COLOR CHANGES, ETC.	N/A	HORIZONTAL STREAKS ON LINES	N/A	N/A	TRANSMISSION TIME IS INCREASED.	SEE ADDENDUM GECJ-2	N/A	N/A
3.DOES RECEIVER (DECODER) MAINTAIN COMPLETE SYNCHRONIZATION (I.E. VERTICAL, LINE, AUDIO, ETC.)?	N/A	YES	N/A	N/A	YES	SEE ADDENDUM GECJ-2	N/A	N/A
4.IF SCRAMBLING/ENCRYPTION SYSTEM IS SUPPLIED, IS DESCRAMBLING/DECRYPTING AFFECTED?	N/A	N/A	N/A	N/A	----	SEE ADDENDUM GECJ-2	N/A	N/A
D.CONDITION 4; DATA LINK BIT ERROR RATE IS 10E-3 OR LESS								
1.ARE ERRORS PERCEPTIBLE?	N/A	YES	N/A	N/A	NO	SEE ADDENDUM GECJ-2	N/A	N/A
2.DESCRIBE VISUAL EFFECTS OF ERRORS - BLOCKS, LINES, STREAKS, COLOR CHANGES, ETC.	N/A	TOTALLY DISTORTED PICTURE	N/A	N/A	TRANSMISSION TIME IS INCREASED.	SEE ADDENDUM GECJ-2	N/A	N/A
3.DOES RECEIVER (DECODER) MAINTAIN COMPLETE SYNCHRONIZATION (I.E. VERTICAL, LINE, AUDIO, ETC.)?	N/A	NO	N/A	N/A	YES	SEE ADDENDUM GECJ-2	N/A	N/A
4.IF SCRAMBLING/ENCRYPTION SYSTEM IS SUPPLIED, IS DESCRAMBLING/DECRYPTING AFFECTED?	N/A	N/A	N/A	N/A	----	SEE ADDENDUM GECJ-2	N/A	N/A

Table 3-7 COMPRESSION TECHNIQUE.

COMPANY NAME	COLORADO VIDEO, INC.	NEC AMERICA INC.	ROBOT RESEARCH, INC	MARCOM	INTERAND CORPORATION	G.E.C.JERROLD LIMITED	GRINNELL SYSTEMS	E-SYSTEMS, INC.
4. COMPRESSION TECHNIQUE								
A.GENERAL TYPE OF COMPRESSION (TRANSFORM, DPCM, RUN LENGTH, 2 DIMENSIONAL,ETC.)	NONE	DPCM AND VARIABLE LENGTH CODING	N/A	PROPIETARY AT THIS TIME.	TWO DIMENSIONAL, MULTIPLE PASS COMPRESSION. IMAGE IS RECEIVED IN FOUR SEC AT 9600 BITS/SEC. RESOLUTION IS THEN INCREASED AS FUNCTION OF TIME OR OTHER INSTRUCTION.	USER SELECTABLE; 4-BIT DPCM OR 2-9 BIT VLC.	N/A	DISCRETE COSINE TRANSFORM SEE ADDENDUM ESI-1
B.COMPRESSION RATIO ACHIEVED (COMPARED TO PCM - VENDOR'S DESCRIPTION-BIT RATES,ETC.)	N/A	3:1 TO 8:1 (DEPENDENT ON OPTIONS, TX MODE, AND PICTURE CONTENT).	N/A	2:1	VARIABLE; FOR MOST DOCUMENTS BETTER THAN 4:1.	N/A	N/A	SEE ADDENDUM ESI-1
C.COMPRESSION TECHNIQUE DESCRIPTION (PROVIDE TECHNICAL NOTES, PATENTS VENDOR DESCRIPTION,REFERENCE PAPERS, ETC.)	N/A	HIGH-ORDER DPCM OPTIONED FOR COLOR OPERATION. VARIABLE LENGTH CODING TO STRIP UNUSED BITS FROM CODE. OPTIONAL SUB-NYQUIST SAMPLING.	N/A	PROPIETARY AT THIS TIME.	PATENT PENDING	N/A	N/A	N/A
D.FUTURE GROWTH POTENTIAL OF TECHNIQUE (VENDOR'S DESCRIPTION OF FUTURE PERFORMANCE MODIFICATIONS/IMPROVEMENTS,LOWER BIT RATES,ETC.)	N/A	N/A	N/A	NOT AVAILABLE AT THIS TIME.	COMPRESSION RATIOS OF 10:1 OR GREATER.	N/A	N/A	N/A
E.IMPORTANT ANY ADDITIONAL INFORMATION ON COMPRESSION TECHNIQUE. REASONS WHY VENDOR'S TECHNIQUE SHOULD BE CHOSEN AS THE STANDARD FOR FEDERAL GOVERNMENT TELECOMMUNICATIONS SYSTEMS.	N/A	HIGH STABLE AND BETTER QUALITY FOR COLOR VIDEO SIGNAL.	N/A	---	TECHNIQUE IS VIDEO STANDARDS INDEPENDENT. COMPRESSION TECHNIQUE IS INHERENTLY IMMUNE TO DATA ERRORS.	N/A	N/A	SEE ADDENDUM ESI-1
F.WHAT PARAMETERS DO YOU THINK SHOULD BE STANDARDIZED?	PROTOCOL FOR IDENTIFICATION OF CODING USED.	HO-DPCM	N/A	---	RESOLUTION, SUSCEPTIBILITY TO DATA ERRORS.	N/A	N/A	N/A

Table 3-8

PHYSICAL DESCRIPTION AND SPECIFICATIONS.

PROVIDE COMPLETE PHYSICAL DESCRIPTION OF FREEZE FRAME EQUIPMENT FOR ALL CONFIGURATIONS (TRANSMIT, RECEIVE, DUPLEX, ETC.) PLEASE INCLUDE THE FOLLOWING AS A MINIMUM.

COMPANY NAME	COLORADO VIDEO, INC.	NEC AMERICA INC.,	ROBOT RESEARCH, INC	MARCOM	INTERAND CORPORATION	G.E.C. JERROLD LIMITED	GRINNELL SYSTEMS	E-SYSTEMS, INC.
1.MECHANICAL DIMENSIONS								
A.SIZE - WIDTH	19 INCHES	403 MM	14.5 INCHES	13 INCHES	17 INCHES	MAIN UNIT 525 MM:KEYPAD 223MM	19 INCHES	19 INCHES
HEIGHT	10.5 INCHES	260 MM	7 INCHES	9 INCHES	14 INCHES	335 MM 70 MM	19.25 INCHES	7 INCHES
DEPTH	15 INCHES	400 MM	13 INCHES	6 INCHES	19.5 INCHES	425 MM 215 MM N.B.;19-INCH RACK (DIN 414904)	22 INCHES	21 INCHES
B.WEIGHT	30 LBS.	25.5 KG.	15 LBS.	N/A	93 LBS.	N/A	90 LBS.	50 LBS
C.POWER REQUIREMENTS (BE SPECIFIC)	100/115/230 VAC 50/60 HZ; 120 W	250 W	115V, 60HZ AC OR 220V, 50HZ AC; 25 WATTS.	+15V AT 1 A, -15V AT 2 A, 5V AT 5 A	110V AT 4 AMPS OR 220V AT 2 AMPS	N/A	110 VAC OR 220 VAC, 60 HZ OR 220 VAC 50 HZ.	450 WATTS (MAXIMUM), 115/230 VAC, +/ 10%,SINGLE PHASE, 47 TO 440 HZ
D.ADDITIONAL INFORMATION	SEPARATE REMOTE CONTROL IS 2.5 X 7.5 X 6; 3 LBS.	FRAME ONLY	N/A	HER CARD CAGE	N/A	N/A	N/A	SLIDE MOUNTING IN 19 INCH RETMA RACK, 7 INCH VERT SPACE
2.ENVIRONMENTAL OPERATION								
A.OPERATING TEMPERATURES	0 TO 50 DEGREES C	0 TO 40 DEGREES C.	NOT SPECIFIED 74LS TTL	NOT AVAILABLE AT THIS TIME	0 TO 40 DEGREES C.	N/A	+ 10 TO + 50 DEGREES C	-20 TO +71 DEGREES C.
B.OPERATING RELATIVE HUMIDITY	90%	10 TO 90%	NOT SPECIFIED 74LS TTL	N/A	10 TO 90% NON CONDENSING.	N/A	20 TO 95% WITHOUT CONDENSATION	95% NON-CONDENSING
C.STORAGE TEMPERATURE	0 TO 70 DEGREES C	-20 TO +50 DEGREES C.	NOT SPECIFIED 74LS TTL	N/A	-20 TO +50 DEGREES C.	N/A	---	-54 TO +85 DEGREES C.
D.STORAGE RELATIVE HUMIDITY	90%	10 TO 90%	NOT SPECIFIED 74LS TTL	N/A	0 TO 90% NON CONDENSING.	N/A	---	95 % NON-CONDENSING
E.OPERATING ALTITUDE RANGE OR RESTRICTIONS	NOT KNOWN	NONE	NOT SPECIFIED 74LS TTL	N/A	MAX. 12,000 FT.	N/A	N/A	UNSPECIFIED
F.ADDITIONAL INFORMATION	N/A	N/A	NO ENVIRONMENTAL TESTING OR SPECIFICATIONS HAS BEEN DONE ON THIS SERIES. THEREFORE, THERE ARE NO GOOD ANSWERS TO THESE QUESTIONS.	N/A	N/A	N/A	N/A	N/A
3.EMI/EMC								
A.DOES EQUIPMENT MEET ANY EMI/EMC STANDARDS?	FCC RULES & REGULATIONS PART 15; SUBPART J; CLASS A	NOT TESTED	UNKNOWN	NOT AVAILABLE YET	NO	N/A	FCC SECTION J	NACSEM 5100
B.HAS EQUIPMENT BEEN TESTED TO ANY MIL STANDARDS?	NO	NOT TESTED	NO	N/A	NO	N/A	NO	MIL-STD-461A, NOTICE 3
4.CONNECTORS								
A.PROVIDE COMPLETE DESCRIPTION OF ALL EXTERNAL VIDEO AND SYNC CONNECTORS (TYPE,NUMBER,LOCATION, IMPEDANCE,ETC.).	4 - BNC; REAR PANEL, 75 OHMS	ALL VIDEO CONNECTORS BNC TYPE	BNC CONNECTORS VIDEO OUT AND VIDEO IN.	BNC	ALL VIDEO INPUT AND OUTPUT CONNECTIONS BNC.	4 BNC TYPE FOR VIDEO	BNC ON BACK, 75 OHMS.	(12) D TYPE, DIGITAL I/O, (5) BNC TYPE, VIDEO I/O
B.PROVIDE COMPLETE DESCRIPTION OF ALL EXTERNAL AUDIO CONNECTORS.	NONE	NONE	TO TAPE AND FROM TAPE RCA JACKS (FCC REGISTERED UNITS) 0.25 INCH PHONE JACK (NON FCC REGISTERED UNITS)	NONE	NONE	N/A	N/A	NONE
C.PROVIDE COMPLETE DESCRIPTION OF ALL EXTERNAL POWER CONNECTORS.	STD. IEC CONNECTOR; REMOVEABLE POWER CORD.	AC IN AND OUT. CANNON JAE-XX-C3 3PIN CONNECTORS	3 CONDUCTOR POWER CORD	MOLEX	1 AC CABLE, NEMA 5-15P TO A BPH-386.	N/A	3 PRONG TWIST LOCK.	ONE CIRCULAR MIL TYPE
D.PROVIDE COMPLETE DESCRIPTION OF ALL EXTERNAL TEST AND BITE CONNECTORS.	NONE	RS-232 25 PIN OR V.35 DTE CONNECTOR DEPENDING ON OPTION	N/A	NONE	NONE	N/A	N/A	NONE
E.PROVIDE COMPLETE DESCRIPTION OF ALL OTHER EXTERNAL CONNECTORS TO INCLUDE FUNCTION, TYPE,LOCATION, IMPEDANCE,BIT RATE/BANDWIDTH,ETC.	25-PIN SERIES D DATA CONNECTOR, 14-PIN AMPHENOL BLUE RIBBON REMOTE CONTROL CONNECTOR.	8 SECTION TERMINAL BLOCK AND 2 BRIDGING CLIPS FOR FX MODEM CONNECTION;2, 37 PIN D CONNECTORS FOR REMOTE CONTROL.	N/A	MULTIBUS ACCESSORY CONNECTOR FOR SOFT CONTROLLER	25 PIN MINI D FOR RS-232, 4800 TO 9600	KEYPAD-25 WAY D TYPE SERIAL INTERFACE-25 WAY D TYPE FOR GRAPHICS TABLET, ETC. PARALLEL INTERFACE-25 WAY D TYPE INCLUDES POWER, 8-BIT BI-DIRECTIONAL LOW DATA RATE FOR USER DATA, E.G. REMOTE CAMERA CONTROL. ALARM-15 WAY D TYPE. MODEM 1-15 WAY D TYPE TO NETWORK MODEM 2-25 WAY D TYPE TO NETWORK LIGHT PEN ON BACK OF KEYPAD.	4 EA. - JOYSTICK CONNECTORS, 2 EA. - 15 PIN D FOR FAX INPUT, 1 EA. RS-232 FOR CURSOR INPUT	NONE

Table 3-9

OTHER DATA ABOUT PRODUCT

COMPANY NAME	COLORADO VIDEO, INC.	NEC AMERICA INC.	ROBOT RESEARCH, INC.	MARCON	INTERAND CORPORATION	G.E.C. JERROLD LIMITED	GRINNELL SYSTEMS	E-SYSTEMS, INC.
1.STATUS/ALARMS- PLEASE PROVIDE DESCRIPTION OF STATUS INDICATORS AND ALARMS INCLUDING FUNCTION, LOCATION, TYPE, ETC.	MAIN CHASSIS: POWER ON INDICATOR. REMOTE CONTROL HAS FOLLOWING INDICATORS: SCAN, PAUSE, HOLD, SOURCE (1/2/3),SCAN DIRECTION (N/W), RESOLUTION (HI/LO)	NONE- USER STATUS INDICATORS ON FRONT PANEL LED TYPE INDICATING TX, RX, VIDEO, SELECT, INPUT MONITOR, AND TX MODE.	N/A	NONE	SEE MANUAL.	N/A	N/A	ONE (1)'TEST GO' INDICATOR ON FRONT PANEL.
2.BITE- PLEASE PROVIDE DESCRIPTION OF ANY BITE PROVIDED WITH EQUIPMENT INCLUDING TYPE, FUNCTION, OPERATOR ASSISTED, AUTOMATIC, ETC.	NONE	FM MODEM FOR BW TRANSMISSION AT N 20K BITS EQUIVALENT TRANSMISSION RATE.	N/A	NONE	N/A	N/A	N/A	EACH CIRCUIT CARD HAS ITS OWN POWER-UP DIAGNOSTICS ON BOARD.
3.FRONT PANEL/OPERATOR CONTROLS- PLEASE PROVIDE DESCRIPTION OF ALL FRONT PANEL/OPERATOR CONTROLS INCLUDING FUNCTION BEING CONTROLLED,PROCEDURE, ETC.	MAIN CHASSIS: POWER ON/OFF, VIDEO LEVEL, BLACK LEVEL. REMOTE CONTROL: SOURCE SELECT, FREEZE, SEND, RESET, PAUSE, SCAN DIRECTION, RESOLUTION, HOLD, MANUAL RECEIVE START. ALL OF THE ABOVE MAY BE INCLUDED OR DELETED ACCORDING TO SYSTEM REQUIREMENTS.	CONTROLS PROVIDED: INPUT SELECT, INPUT MONITOR, TX, RESET, AND SINGLE OR MULTIPLE TRANSMISSION CONTROLS. PARTIAL FIELD TRANSMISSION AND READ TIME POINTER PROVIDED WITH REMOTE CONTROL PANEL.	N/A	NONE	SEE MANUAL.	VIDEO SELECT.	POWER SWITCH, ORIENTATION SWITCH, TWO TEST SWITCHES,ONE POLARITY REVERSAL SWITCH.	ONE (1) POWER ON/OFF SWITCH. ONE (1) RESET SWITCH.
4.ENCRYPTION/ SCRAMBLING- PLEASE PROVIDE DESCRIPTION OF ENCRYPTION/SCRAMBLING CIRCUITS PROVIDED INCLUDING ALGORITHM, OUTPUT DATA STREAM COMPOSITION, METHOD OF CHANGING KEY, AND ANY OTHER PERTINENT DATA.	NONE	N/A	N/A	NONE	NONE- COMPATIBLE WITH DOD DIGITAL ENCRYPTION DEVICES.	N/A	N/A	N/A
5.DOCUMENTATION/ MANUALS- PLEASE LIST/DESCRIBE ALL MANUALS AND DOCUMENTATION PROVIDED WITH EQUIPMENT FOR OPERATION, MAINTENANCE, AND REPAIR. PLEASE INCLUDE DOCUMENT DATE, TITLE, AND REVISION NUMBER.	INSTRUCTION MANUAL-MODEL 285 DIGITAL SLOW-SCAN TRANSCEIVER, SEPT. 1980 (MONOCHROME). INSTRUCTION MANUAL-MODEL 285C DIGITAL SLOW-SCAN TRANSCEIVER, OCT. 1981 (COLOR).	ONLY USER MANUAL AVAILABLE. ALL TECHNICAL DOCUMENTATION PROPIETARY.	N/A	NONE	COMPLETE COMMERCIAL TYPE DOCUMENTATION.	N/A	SCHEMATICS, THEORY OF OPERATION, AND CONFIGURATION MANUALS.	N/A
6.BROCHURES/TECHNICAL NOTES- PLEASE PROVIDE COPIES OF ALL BROCHURES AND TECHNICAL NOTES OR OTHER MATERIALS CONCERNING THIS EQUIPMENT, ITS OPERATION, AND ITS APPLICATION.	PROVIDED ARE DATA SHEETS ON THE 723 DMA I/O MODULE AND THE 930 VIDEO IMAGE STORAGE SYSTEM THAT CAN BE USED WITH THE MODEL 285. (AVAILABLE FROM CVI)	SEE BROCHURE. (AVAILABLE FROM NEC)	N/A	NONE	SEE BROCHURES (AVAILABLE FROM INTERAND CORP.)	N/A	N/A	N/A

3.2.6 Supplemental Questionnaire

A supplemental questionnaire sent to the codec vendors requested further detail about the time required to transmit a picture at the data rates specified for the equipment. Information about equipment options and optional features available was also requested.

This data is listed in Table 3-10.

Table 3-10 Transmission Times and Product Options

ADDENDUM TO FREEZE FRAME CODEC V

COMPANY	COLORADO VIDEO, INC.	NEC AMERICA	G.E.C. JERROLD LIMITED
1. TRANSMISSION TIMES.			
PLEASE PROVIDE TOTAL TRANSMISSION TIMES FOR EACH TRANS- 2. SECTION 3, PARAGRAPH d, TITLED-OUTPUT BIT RATE-ON PAGE 5 OF THE QUESTIONAIRE.	THE 285 WILL OPERATE AT ANY RATE IN THE 0 TO 500 K BIT/SEC RANGE (0 TO 200 K BITS/SEC FOR THE (285C). TYPICAL TRANSMISSION TIMES ARE GIVEN IN A CHART ON THE DATA SHEETS ON THESE UNITS (COPIES ENCLOSED). (AVAILABLE FROM CVI)	DETAIL MODE ELC / VLC 4.8 KBIT 130 SEC. 90 SEC. 9.6 KBIT 65 SEC. 45 SEC. 19.2 KBIT 33 SEC. 23 SEC. 56 KBIT 11 SEC. 8 SEC. 240 KBIT 2.6 SEC. 1.8 SEC. 1544 KBIT 0.4 SEC. 0.3 SEC. HIGH SPEED MODE 4.8 KBIT 80 SEC. 50 SEC. 9.6 KBIT 40 SEC. 25 SEC. 19.2 KBIT 20 SEC. 13 SEC. 56 KBIT 7.5 SEC. 4.5 SEC. ELC;EQUAL LENGTH CODE. VLC;VARIABLE LENGTH CODE VLC TIMES ARE AVERAGE AND VARY WITH PICTURE CONTENT.	MONO; 256 X 256 -6 SEC. APPROX. 512 X 512 -18 SEC. COLOUR; -27 SEC. (USING 4-BIT DPCM)
2. OPTIONS AND OPTIONAL FEATURES. PLEASE PROVIDE A LISTING, DESCRIPTION, PRICING, AND ANY OTHER DATA DEEMED IMPORTANT OF ALL OPTIONS AND OPTIONAL FEATURES FOR INCLUSION IN PART 5 OF THE QUESTIONAIRE.	A.DUAL MEMORIES- AN OPTIONAL SECOND MEMORY PROVIDES FOR ADDITIONAL FLEXIBILITY AT BOTH THE TRANSMIT AND RECEIVE LOCATIONS. B.EIGHT-BIT GRAY SCALE- AN EIGHT-BIT OPTION GIVING 256 GRAY SHADES IS AVAILABLE FOR CRITICAL APPLICATIONS. C.COMPUTER I/O- A SPECIAL I/O PORT OPTION WHICH ALLOWS INTERCONNECTION TO AN EXTERNAL COMPUTER OR MASS STORAGE DEVICE. THIS CAPABILITY PROVIDES THE 285 WITH OBSOLESCENCE PROTECTION, AS THE BASIC DIGITAL/VIDEO CIRCUITRY MAY BE USED WITH AN AUXILLIARY COMPUTER FOR NEARLY ANY FORM OF IMAGE PROCESSING, DATA COMPRESSION, OR PACKET SWITCHING. THE COLORADO VIDEO 930 DIGITAL DISC VIDEO IMAGE STORAGE SYSTEM USES THIS OPTION.	PLEASE REFER TO THE ATTACHED PRICE SCHEDULE. (AVAILABLE FROM NEC).	
ADDITIONAL COMMENTS.	PRICES FOR THESE OPTIONS AND FOR THE 930 SYSTEM ARE SHOWN IN THE ENCLOSED PRICE LISTS. (AVAILABLE FROM CVI).		

SECTION 4.0

COMPARISON OF FREEZE FRAME CODECS

4.0 Comparison of Freeze Frame Codecs

4.1 Approach

In the previous task, the data which was collected in the questionnaires was catalogued. Comparisons of the various codecs have been made and are reported in this section. It should be pointed out that the data used in these comparisons has been supplied by each codec vendor - no data or specifications have been verified by an independent source. Nor was the information reported in the questionnaire compared to that in the data sheets.

4.2 Key Specification and Performance Parameters

The questionnaires submitted to the codec vendors requested extensive information about each codec. There are some specifications and performance criteria which are deemed more important to overall codec performance than are others. These particular specifications will therefore be compared in the remainder of Section 4.0 of this report.

4.3 Abbreviations

In the tables and graphs contained in this section the following abbreviations are used to identify the codec questionnaire respondees:

CVI	Colorado Video, Inc.
NEC	NEC America, Inc.
RRI	Robot Research, Inc.

MAR	Marcom
INT	Interand Corporation
GEC	GEC-Jerrold, Ltd
GRI	Grinnell Systems
ESI	E-Systems, Inc.

The additional abbreviations below are used to indicate vendor responses to some questions.

CP	Company Proprietary
NA	Not Available or No Response
TBD	To Be Determined

4.4 Resolution Comparisons

4.4.1 Video Input Signals

The data received from the various codec vendors regarding the video input signal specifications for their devices is listed in Table 3-3. Analysis of this data shows trends and commonalities in the specifications of the equipments designed specifically for "live" teleconferencing as well as uniqueness in specifications of the equipment designed for teleconferencing using primarily hardcopy. The data is summarized in Table 4-1. The following paragraphs list the common input specifications.

The input signal format is uniquely defined for the codecs specifically designed for operation in the U.S. and for the U.S. operational options of foreign codecs. For color operation NTSC is the only choice as is RS-170 for monochrome operation. In the one case where the video input is provided by a TV

Table 4-1 Input Video Signal Comparison

SPECIFICATION	CLI	NEC	RRI	MAR	INT	GRI	GEC	ESI
NTSC - (Color)	X	X		*1X		N/A		
RS-170 (Mono)	X	X	X	X		N/A		X
Other			CCIR		R,G,B +SYNC	N/A	CCIR RGB Y,U,V	
Color/Mono	BOTH	BOTH	MONO			N/A	BOTH	MONO
Amplitude (V.P-P)	1	1	1	1	1	N/A	1	1
Impedance (Ohms)	75	75	75	75	75	N/A	75	75
Composite/Non-Comp. Video	COMP	COMP	COMP	COMP		N/A	COMP	
Sep. Ext. Eync Required	NO	NO	NO	NO	YES	N/A	NO	YES
Balanced (B)/Unbalanced (U)	U	U	U	U	U	N/A	U	U
No. of video inputs	1	5	1	1	EXP. TO 8	N/A	6 MONO 2COLOR	1

*1 Not on response to questionnaire but included in data sheet

camera which is an included fixed part of the codec system, the video signal is RGB and sync.

All codecs except one are available with monochrome and color operation options. The video input signal, where specified, is unbalanced with an amplitude of 1 volt peak-to-peak into a 75-ohm impedance. Only INT and ESI require a separate sync input: they do not specify whether the input signal is composite or non-composite. Of the seven vendors who defined the number of video inputs, three provide codecs with built-in video switches. The remaining four are equipped for only one video input signal.

4.4.2 Video Output Signals

Table 4-2 tabulates the specifications of the video output signals. Commonalities among vendors for each specification are quite apparent. The NTSC format is used as the basis for the output video signal but note that the specific responses are "NTSC compatible," "NTSC type". This can be of great importance depending on the intended use of the output signal. The same comment applies to monochrome output signals in their conformance to the RS-170 format. The fact that some vendors provide single field imagery is the major reason for the deviations from the exact standards of the NTSC and RS-170 signal formats. In their full frame transmission options, some vendors provide full compliance with the appropriate standards.

Table 4-2 Output Video Signal Comparison

SPECIFICATION	CLI	NEC	RRI	MAR	INT	GRI	GEC	ESI
NTSC - (Color)	NTSC COMPAT-IBLE	NTSC TYPE		X *1				
RS-170 (Mono)	X		NON INT.	X				X
Other					R,G,B +SYNC	RS-343	CCIR: R,G,B Y,U.V	
Color/Mono	BOTH	BOTH	MONO	BOTH	BOTH	MONO	BOTH	MONO
Amplitude (V.P-P)	1	1	1	1	0.75	1	1 *2	1
Impedance (Ohms)	75	75	75	75	75	75	75	75
Composite/Non-Comp. Video	COMP	COMP	COMP	COMP		COMP	COMP	COMP
Sep. Ext. Eync Required	NO	NO	NO	YES	YES	YES	NO	YES
Balanced (B)/Unbalanced (U)	U	U	U	U	U	U	U	U
No. of video inputs	1	2	1	1	1 set		2 sets	4 max.

*1 Not on response to questionnaire but included in data sheet

*2 Luminance (Mono, Green, or Y) 0.7 V.p-p Plus 0.3V Sync; Chrominance (Red, Blue, or U, V) 0.7 V.P-P.

The remaining entries are consistent among vendors as would be expected since their equipments are to interface with conventional switching, display, and recording devices.

4.4.3 Vendor Resolution Data

The information provided by the codec vendors regarding resolution is summarized in Table 4-3. The data is presented in the terms used by the vendors to avoid any errors which might be made in converting to common standard units. For answers to detailed questions which cannot be resolved from the data as presented here, the reader is invited to contact the vendor or his representative directly. The data presented here is adequate to support the conclusions drawn.

The responses provided by the codec vendors regarding horizontal pixels when compared to the sampling rate stated must be analyzed with some care. It is not clear that horizontal pixels means "number of resolvable elements per active picture width". For example, given a specific sampling rate, the number of pixels in a given time interval is the product of the time interval and the sampling rate. From this formula the number of pixels for various sampling rates is shown in Table 4-4.

TABLE 4-3; RESOLUTION PARAMETER COMPARISON

SPECIFICATION	CVI	NEC	RRI	MAR	INT	GRI	GEC	ESI
PIXELS								
HORIZONTAL	256/512	684	256	512	640	N/A	MONO;256/512/768 COLOR;LUM.512 CHR.256	512
VERTICAL	240/480	256/525	256	512	484	N/A	MONO;256/512 COLOR;LUM.512 CHR.256	
FIELD/FRAME	FIELD STD. FRAME OPT.	FIELD STD. FRAME OPT.	FIELD	FRAME	FRAME	N/A	256-FIELD 512-FRAME	FRAME
PRECISION								
LUMINANCE	6-BIT STD. 8-BIT OPT.	8-BIT	N/A	8-BIT	3%	N/A	8-BITS	N/A
CHROMINANCE	N/A	N/A	N/A	8-BIT	6%	N/A	N/A	N/A
VIDEO FREQUENCY RESPONSE	4MHZ	UP TO 400 TV LINES(H)	2.5MHZ	4.2MHZ	2MHZ	N/A	N/A	N/A
SAMPLING RATE								
HORIZONTAL	5.5/10MHZ	10.8MHZ	5MHZ	10.33MHZ (COMP.)	LUM.12MHZ CHR.3MHZ	N/A	4.5/9/13.5 MS/S	15,750H
VERTICAL	15,750 HZ		15,750HZ	525	N/A	N/A	N/A	33.3 MS.

Table 4-4. Pixels versus Sampling Rates

Sampling Rate MHZ	Pixels/Active Line Interval (51.5US)	Pixels/Total Line Interval (63.5US)
10	515	635
10.8	556	686
5	258	318
10.33	532	656
12	618	762
13.5	695	857

The above concept can also be applied to vertical sampling. In a single field there are only about 240 active lines; therefore this represents the maximum number of resolution elements which can occur vertically. When this analysis is applied to the sampling rate information supplied, it appears that the codec resolution in terms of pixels/active line fall into three categories. Disregarding precise values and using terms common to the industry as headings, these categories, together with the field/frame relationship are shown in Table 4-5 below.

Table 4-5. Resolution Categories of Codecs

Category	Field/Frame	Vendors
256 x 256	Field	CVI, RRI, GEC
512 x 512	Frame	CVI, NEC, MAR, INT, GEC, ESI
other		
512 x 256	Field	CVI, NEC
768 x 512	Frame	GEC

One further comment is that in the above discussion resolution

has been stated in pixels where pixels are defined as picture samples. These numbers are subject to modification by a factor (similar to the Kell factor) to convert to true resolution in television terms; namely, lines resolvable from a test chart in a width of a picture equal to the height.

Clearly, all vendors have carefully considered resolution as an important item. The similarities, which are obvious when the preceding analysis has been performed on the questionnaire data, indicates that they have reached the same conclusions as to the best categories of resolution parameters to provide. Experience over the years has shown these to be good selections.

A factor which, depending on the application, is as important as resolution is precision of the gray scale encoding. Only 5 of the vendors provided information on the precision of coding. It is not clear in all cases whether this is the equivalent transmitted precision or the precision used to store the picture prior to transmission. None-the-less, six bit precision to eight bit precision is the almost unanimous range of encoding precision provided with the exception of INT who specifies 3% for luminance and 6% for chrominance. It is also not always clear whether the initial freeze frame storage is in composite or component digital form. MAR specified 8-bit luminance and 8-bit chrominance which may indicate component processing. INT and GEC use component techniques.

On the other hand CVI, and NEC indicate only a luminance precision which suggests composite storage. This could be further extrapolated to mean that if component encoding transmission is used, digital color decoding is performed.

The frequency response data is not clear. In general the bandwidth listed will support the upper range of the pixel options provided and therefore is not a discriminator as far as resolution is concerned. An exception is INT where the bandwidth specified is 2 MHZ which cannot support 640 x 484 pixels in a standard TV display format.

4.5 Analog TV Performance Measurement Comparisons

4.5.1 Applicability to Digital Codecs

There is much discussion among digital TV engineers about the significance of analog TV performance measurements, commonly used in the broadcast TV industry, to measure TV quality applied to digital television codecs. Without entering the argument, it does appear that the standards used in analog TV systems for such video test signal measurements as differential phase and gain, video frequency response, etc. provide the upper limit that a digital TV codec could achieve. In other words, digital codecs in general will not perform as well. A good portion of the codec is analog in nature; for example, most of the NTSC encoders and decoders, the video amplifiers, the anti-alias filters are generally analog. The characteristics of these circuits directly affect the quality of the test signals passed through them.

In addition, there are other useful purposes in employing video test signals to characterize television systems; they can be used to perform comparative evaluation of properly functioning equipments and can be used to diagnose malfuncting equipments.

Relative standards among the codecs thus can be important.

4.5.2 Vendor Measurement Data

Table 3-5 contains the vendor supplied analog performance measurements for various video test signals. Again, it is noticed that only 3 vendors provided essentially any measurement data. The data provided in the response is summarized in Table 4-6 which gives the ranges of the measurements or calculations.

4.5.3 Summary of Measurement Data

The most immediate observation is that in general these data are better than that previously presented in response to a questionnaire regarding motion codecs, several from the same vendors. In fact, the performance cited by the better entries is excellent considering that NTSC decoding, anti-alias filtering, component filtering, A-D conversion, compression, D-A conversion, NTSC encoding, and additional filtering may all be involved. A word of caution is noted as the exact measurement technique, procedure, and test equipment used were not specified by the vendors.

Table 4-6 Comparison of Video Test Signal Performance

Specification	Range
Luminance to Chrominance Gain Inequality	None, 2%, $<$ 6%
Luminance to Chrominance Delay Inequality	$<$ 100 ns, 2%, $<$ 42ns.
Short Time Waveform Distortion	None, 5 ns.
Signal-to-Quantizing Noise Ratio	$>$ 40 dB, 46.5 dB, 52 dB ½LSB
Differential Gain	2%, $<$ 4%
Differential Phase	2 degrees, $<$ 2 degrees
Field Time Waveform Distortion	$<$ 1%, 1%
Line Time Waveform Distortion	$<$ 1%, 1%

4.6 Vendor Compression Technique Comparisons

4.6.1 Overview

Brief descriptions of each vendors' codec is contained in this section based on information supplied by the vendor. Where available, detail about the various coding subsystems is provided. Performance limitations of the codecs are listed. A measure of the codec/compressor complexity is provided by comparing size, weight and power requirements.

Additional information was solicited concerning product life, planned improvements, and future growth potential. This data is shown in Table 3-1. Information about pricing is also detailed in Table 3-1. Other data regarding spares, maintenance, and training is in Table 3-2. Connector interface data is shown in Table 3-8.

4.6.2 Compression Descriptions

It is, of course, realized that the compression algorithm and its implementation form the heart of the codecs investigated in this study with one exception discussed subsequently. The ability to minimize the time required to transmit a picture is the goal of vendors in the codec competition for video teleconferencing. This competition has led them to develop equipments with the ability to remove, eliminate, or reduce the amount of digital video information to be transmitted at a given bit rate while maintaining an acceptable displayed picture. The exception to this rule is CVI whose codec generates a PCM output digital video signal

which is uncompressed but can be transmitted readily. Apparently the rationale is that the user can design/procure a device, possibly a small scale computer with the appropriate software, to compress the PCM output signal using any of the compression techniques desired if it is necessary to reduce the transmission time. The concept of a software controlled compression unit may ultimately lead toward compression adaptability and standardization.

None of the codec vendors have implemented compression techniques which are compatible with any other vendor as far as can be determined at this time. Two vendors, RRI and GRI did not provide an input as to the compression technique utilized. MAR stated that their compression technique is proprietary at this time.

Information regarding the coding techniques used by the vendors was very limited. NEC utilizes HO-DPCM which is a High Order Differential Pulse Code Modulation technique in which the video data is compressed using DPCM. The codecs assigned to the resulting data are optimized to produce further compression The INT coding is defined as two dimensional, multipass compression and little other information is available. It appears that each pass provides additional data to enhance the display up to a given point. Forward Error Correction (FEC) is used.

GEC uses operator selectable 4-bit DPCM or 2 to 9 bit variable length coding (VLC). No details are provided. ESI utilized Discrete Cosine Transform (DST) coding.

This data is summarized in Table 4-7.

TABLE 4-7 COMPRESSION SUMMARY

	COMPRESSION TECHNIQUE	COMPRESSION RATIO
CVI	NONE: OUTPUT IS PCM	N/A
NEC	DPCM AND VARIABLE LENGTH CODING	3:1 to 8:1 (DEPENDENT ON OPTIONS, TX MODE, AND PICTURE CONTENT.)
RRI	N/A	N/A
MAR	PROPRIETARY	2:1
INT	TWO DIMENSIONAL MULTI-PASS COMPRESSION	VARIABLE: FOR MOST DOCUMENTS BETTER THAN 4;1
GEC	4-BIT DPCM, 2-9 BIT VLC (USER SELECTABLE)	N/A
GRI	N/A	N/A
ESI	DISCRETE COSINE TRANSFORM	N/A

4.6.3 Codec Performance Limitations

One evaluation of codec performance is based on resolution (others are transmission time, gray scale, etc.) Resolution is a function of analog circuit bandwidths, sampling density, and on the compression algorithm used. As mentioned in Section 4.4.3, Vendor Resolution Data, it is difficult to determine commonalities between data presented by the various vendors. An analysis was made on sample data to serve as an aid to the reader in his comparative evaluation of the data.

It is impossible to assign the contribution of the three determining elements to the system resolution. Therefore the following summary is presented using data as presented by the vendor. Refer to Table 4-8.

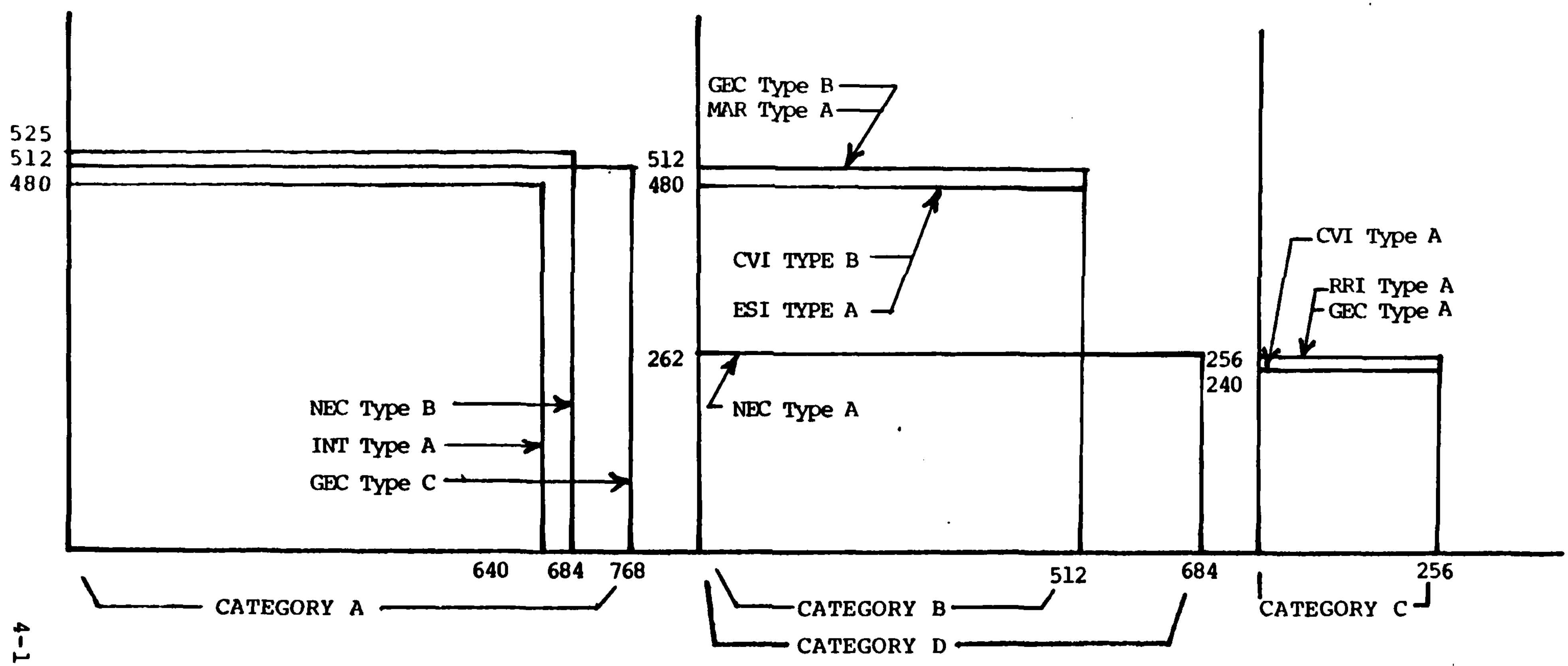
Looking at the maximum number of pixels to represent (resolve) an image, the GEC Option C codec clearly has the largest number of pixels available at 393,216. The NEC Option B terminal has 359,100 pixels while INT has 309,760. It would be interesting if a percentage relationship could be stated between each of the codecs; however, since the method of measuring resolution and the data provided by the vendors is not precisely defined, such a process would have little validity. However, for the purpose of establishing categories of resolution, a further attempt at comparison is presented in Figure 4-1.

TABLE 4-8 COMPRESSION/CODEC PERFORMANCE LIMITATIONS*

VENDOR	OPTION	HORIZ.	VERT.	PRODUCT	RESOLUTION CATEGORY
CVI	A	256	240	61,440	C
CVI	B	512	480	245,760	B
NEC	A	684	262	179,208	D
NEC	B	684	525	359,100	A
RRI	A	256	256	65,536	C
MAR	A	512	512	262,144	B
INT	A	640	484	309,760	A
GEC	A	256	256	65,536	C
GEC	B	512	512	262,144	B
GEC	C	768	512	393,216	A
GRI	A	N/A	N/A	N/A	N/A
ESI	A	512	480	245,760	B

* USING DATA AS SUPPLIED BY VENDOR

Figure 4-1. Summary of Codec Resolution



The three codecs previously described above have over 300,000 pixels per image. For purposes of nomenclature these are categorized as group A. A second category, B, becomes obvious when examining Table 4-8. These codecs range between 245,000 and 262,000 pixels and are also depicted in Figure 4-1.

Finally, a third category, C, is apparent; these codecs have about 65,000 pixels and are depicted in Figure 4-1. Only one entry does not fall directly into one of these categories and that is NEC option A. This codec provides 684 horizontal pixels and 262 vertical pixels for a total of 179,208. It has been assigned to Category D. This category is shown superimposed on Category B in Figure 4-1.

The conclusion drawn from the above is that four general categories of imagery resolution exist among available codecs. Figure 4-2 shows the resolution relationship among the generalized categories.

4.6.4 Codec Complexity Comparisons

The information shown in Table 4-9 provides insight into the complexities associated with each codec. For example, from the physical sizes provided by the vendors, a volume was calculated for each codec which shows a substantial variation in volume ranging from 702 cu.in. for the MAR unit to about 4500 cu.in. for INT and GEC. Note that the GRI unit is a system including more than a codec. For users who have space constraints, the codec size could be important. Also, the weight data is somewhat

Figure 4-2 GENERAL RESOLUTION CATEGORIES

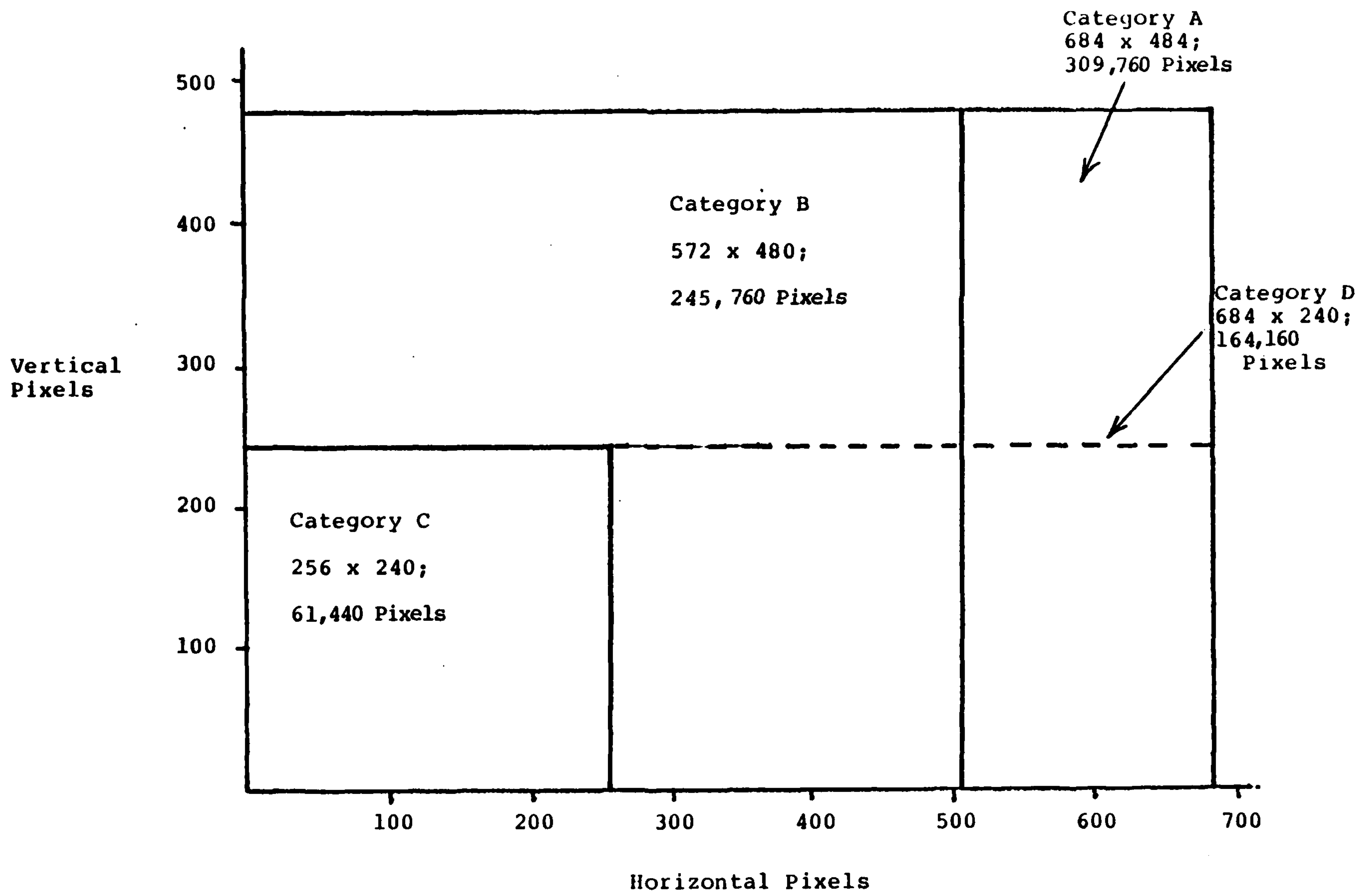


TABLE 4-9 COMPLEXITY COMPARISONS

COMPLEXITY CHARACTERISTIC	CVI	NEC	RRI	MAR	INT	GEC	GRI	ESI
1. Model Number/Description	285	TVS-783	600 series Telepix		DISCON 1000	SLOW SCAN II	GMR 27-671	N/A
2. Size (Inches)								
Height	19	19	14.5	13	17	20.7	19	19
Width	10.5	10.24	7	9	14	13.2	14.25	7
Depth	15	18.9	13	6	19.5	16.7	22	21
Calculated Vol (CU. IN.)	2992.5	3677.2	1319.5	702.0	4641.0	4563.1	8046.5	2793
3. Weight (Pounds)	30	56	15	N/A	93	N/A	90	50
4. Power Requirements (Watts)	120	250	25	55	440	-	-	450

similar to volume data ranging from 15 to 93 lbs.

The power requirement is another indication of the electronic complexity of the codec. From the data supplied in Table 4-9, it appears that perhaps both complexity and technology contribute to the substantial range of power requirements (25 watts to 450 watts). One could thus conclude that the RRI codec requiring only 25 watts has probably considerably less circuitry than the other codecs.

The operational environmental data can be reviewed in the Table 3-8. For the codecs shown, all will operate under similar temperature ranges and relative humidity conditions.

4.6.5 Product Life

In Table 3-1 there are comparisons of various factors concerning the product life of the codec as provided by the codec vendors. The range of codec product life is listed from 3-5 years with an average span of 3 years. One vendor indicates that all upgrades will be compatible with present codecs. Since there are no universal guidelines which dictate how to specify product life, the significance of this information is somewhat limited.

Of more importance is the announced improvements and modifications as shown in Table 3-1. In general emphasis is placed primarily upon control improvements including the use of micro processors. CVI plans to add compression to their codec which presently employs PCM transmission. GEC plans include an NTSC version for U.S. standards.

4.6.6 Codec Pricing and Delivery

The data contained in Table 3-1 was supplied by the vendors specifically for this study. As can be seen only three vendors responded with price sheets. It is advised that the reader contact the vendors for prices because of the wide variety of combinations of base units and options. Comparisons cannot be made in a meaningful manner with only three out of eight responses.

Delivery of hardware in the recent years has varied tremendously with the availability of components at any specific time. It is necessary to obtain delivery information from the vendor for the specific period of interest.

4.7 Digital Interfaces and Specifications

4.7.1 Discussion of Interfaces

In this section, the comparison of codecs is made by studying their digital interfaces. Included in the comparisons are transmission channel bit rates, channel data formats and other digital data inputs and outputs to the codec. Of the vendors who responded, only one does not use digital transmission in its true sense but modulates an FM carrier in correspondence with signal amplitude.

The digital transmission channel interface is described as a specification usually associated with a format and hierarchy of digital transmission. For the codecs in this study, there are two specifications applicable to use in the United States (RS-232C and MIL-STD-188C) and two for use in Europe (V.24 and V.35). These

specifications have been in use for many years. They are thoroughly specified as to signal amplitude, rise time, fall time, data rates, controls, channel considerations, connectors, etc.

The data rates for which these specifications apply cover a wide range. For example, RS-232 specifications cover the range from very low data rates up to 19.2KB/S. Thus, most of the applications for which the codecs are designed can be satisfied by data channels which are compatible with the appropriate one of the four formats cited. The manufacturers have designed their codecs either for specific data rates such as those compatible with conditioned V.F. lines or have provided the flexibility in the output data rate to cover a number of the data rates in the standard digital hierarchy. Among these data rates are 19.2, 56, 64, 256KB and even the T-1 rate of 1.544 MB.

4.7.2 Transmission and Data Channel Comparisons

Table 3-4 contains the comparison of the major characteristics of the transmitted channel bit rate for each codec. It is noted that all vendors provided responses for transmission rates which vary from low rates to 1.5 MB/S. Several are apparently designed for specific data rates; e.g., ESI 2400 BPS; INT; 4800, 7200, and 9600 BPS. Others such as CVI, GEC, NEC and MAR track an input clock over a very wide range. These are dependent on the modem used in any specific application. Interface connectors are those which are specified by the communication standard.

4.7.3. Equipment Data Format Comparisons

Each vendor was asked to provide detailed information about

the composition of their codec transmitted bit stream. Only two vendors provided specific information; CVI and GEC. CVI uses PCM transmission with the four lowest codes providing video sync and control. GEC protocol is based on X-25 packet compatibility. The other vendors indicate that their protocol is proprietary, special or nonstandard.

4.7.4 Summary of Digital Interface Data

In the previous subsections, comparisons have been made of the various digital interfaces of the codecs. If codecs are to be compatible and interoperable between different vendors, then, of course, the codec processing (compression) algorithms must be compatible. In addition, the three digital interfaces of the transmitted bit stream must be standardized - (1) equipment data interface, (2) data channel interface, and (3) the transmission channel interface.

None of the codec vendors indicate that they provide both asynchronous and synchronous transmission. Four vendors incorporate the synchronous data channel interface. These also operate over a wide range of data rates. Only one vendor has data channel standards for asynchronous transmission and that at 2400 BPS. Two vendors provide no data while a third uses a modulated FM carrier.

The information provided does not permit analyzing the assignment of the total number of bits allocated for transmission into categories such as transmission overhead, video data, video sync, FEC, etc. Given the data rates and transmission time, the picture size in pixels and the compression ratio specified, the impression is that the transmission efficiency is generally high. Much more

detailed information is required in order to determine and publish exact values.

A proposal should be considered to establish a codec and transmission data frame standard for video teleconferencing. It is premature at this time because all details of the vendor codecs have not been reported and the performance of these codecs have not been observed nor compared with other codecs. Considerable study and evaluation of the codecs is necessary using standard measurement techniques to make meaningful performance comparisons.

4.8 Bit Error Performance

4.8.1 Discussion

The bit error performance of freeze frame codecs is significant as the overall performance of the codec could be greatly affected by the number of and the manner in which data link errors alter the compression algorithm processing in the receiving portion of the codec. It is generally well known that as higher compression ratios are employed in codecs, the effect of a bit error upon the compression process is greater.

In a one dimensional TV compression technique such as delta modulation, a bit error can affect several or all the pixels in the same TV line. In a two dimensional compression technique pixels in an area are generally affected by a bit error.

Codecs can employ forward error correction (FEC) coding which provides for the detection and correction of data link bit errors.

There are several methods and degrees of error correction which can be incorporated in the codec. FEC, however, does require that additional transmission bits be assigned for this purpose which in effect reduces the overall compression efficiency of the codec.

Bit errors generally occur in random fashion on data links. Usually on transmission channels used for video conferencing, such as satellites, successive bit errors can occur due to burst-type noise effects. Thus, some codecs provide FEC which will correct single error bursts up to 9 bits in length.

In the vendor questionnaire, several subjective questions and visual effects were asked about the codec operating in various bit error conditions. No objective measurements were specified in the questionnaire due to the lack of having standardized video inputs, standardized techniques for contaminating the transmitted bit stream, and standardized measurement techniques to apply to the decoded TV picture. Thus, the results presented in the following subsections represent the vendors answers to the questions.

4.8.2 Subjective Measurements

The questions asked about the codecs were limited to subjective evaluations as noticed in observing the quality and effects of bit errors in the codec output picture. A basic observation was to determine if the errors were perceptible at each of four bit error rates. If errors are perceptible, then the type of effect was to be described such as blocks, streaks, flashing lines, color changes, etc.

Another question related to ability of the codec receiver to maintain synchronization of the TV image including horizontal,

vertical, audio, etc. Finally, the effect of bit errors upon the encrypting/decrypting process, if employed in the codec, was to be specified. This could be important because an error in an encrypted signal could be multiplied into several errors due to the encryption process.

4.8.3 Comparison of Bit Error Performances

Table 3-6 contains the comparisons of the various codecs under bit error rates ranging from 10^{-6} to 10^{-3}. An important consideration in comparing the performance of codecs under varying bit error rate conditions is whether the codec has either a built-in or optional Forward Error Correction (FEC) subsystem. In the codecs listed in Table 3-6, INT has built-in FEC circuitry. CVI transmits the video data uncompressed as PCM data. ESI, MAR, GRI did not provide information on BER performance. RRI transmits video data by FM modulating a carrier. BER performance has no relevance to this transmission technique nor was any additional data provided.

For a BER of 10^{-6} (Table 3-6) only INT reports no perceptible visual degradations due to errors because of the FEC. However, CVI indicates that errors cause dots in the picture as is to be expected with PCM transmission. NEC, who uses HO DPCM compression, states that errors will cause streaks on picture lines. NEC and INT state that synchronism is maintained. When the BER is 10^{-5} (Table 3-6), NEC indicates errors cause streaks presumably somewhat more severe while INT states that errors are corrected. Both maintain synchronism. Based on experience with PCM transmission of video data, it is expected that CVI's presentations will maintain synchronism but contain a larger number of dots.

At 10^{-4} BER the reported performance of the codecs remains the same except that INT required an increased amount of transmission time to support the FEC. CVI performance was not stated for the PCM transmission.

For operation at 10^{-3} BER (Table 3-6) NEC indicates that the picture is totally distorted while INT states that the transmission time is further increased and snychronism is maintained and errors are still not perciptible. CVI performance was not stated for the PCM transmission.

4.8.4 Summary of Bit Error Performance

In reviewing the codec performance data supplied by the vendors for various BER's as shown in Table 3-6, it is difficult to evaluate the performance of the various codecs in comparison to each other or on an absolute basis because of the lack of data in the responses. Consideration of the data which was presented by NEC, CVI and INT has lead to the design of a Table 4-10 shown below as to the useability of each of these three codecs for teleconferencing applications. This table must be verified by controlled expermintal evaluation before it can be considered final.

Table 4-10. Codec Teleconferencing Applicability

BER	NEC	CVI	INT
10^{-6}	Good	Good	Excellent
10^{-5}	Adequate	Presumably Adequate	Excellent
10^{-4}	?	?	Adequate
10^{-3}	?	?	Adequate

SECTION 5.0

IDENTIFICATION AND QUANTIFICATION OF POTENTIAL STANDARDIZATION PARAMETERS

5.0 Identification and Quantification of Potential Standardization Parameters

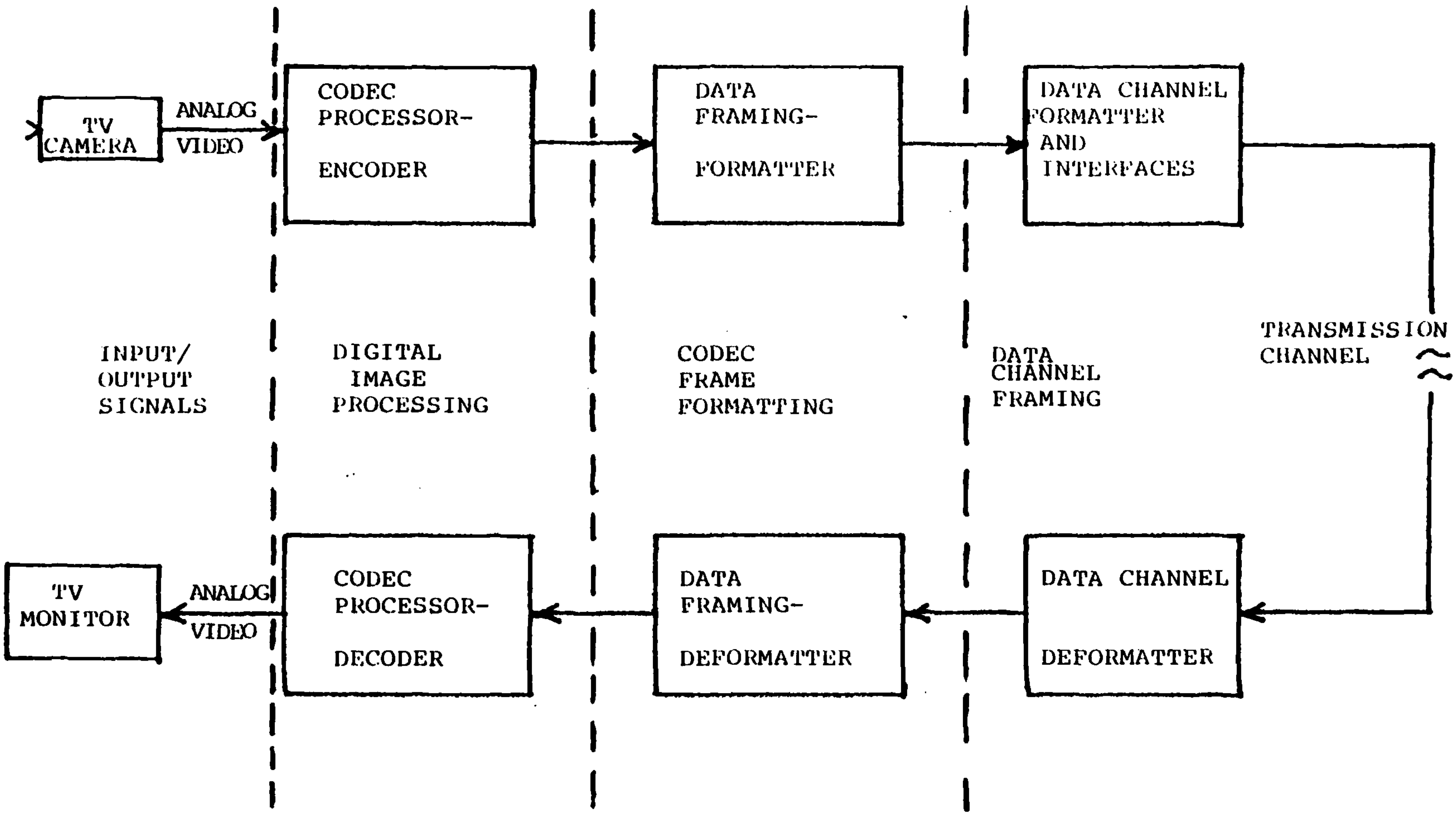
5.1 Discussion

The comparative information obtained from the previous sections form the basis for the identification of codec parameters which should be considered for potential standardization if interoperability of video teleconferencing systems is to be achieved among and within Federal Government agencies. It has been shown that there are several functions involving many parameters which must be standardized to achieve complete interoperability between codecs; examples are video inputs, compression algorithm processors, codec digital output formats, and data channel formats. In addition to the above bit and data requirements, there are TV performance standards involving the quality of the displayed picture which should be determined for minimum acceptable performance for teleconferencing applications.

In Figure 5-1, a model of a functional video teleconferencing system is shown to help identify further the categories of possible standards applicable to video teleconferencing. For convenience, four groups of possible standards have been selected for purposes of discussion and identification of parameters.

1. Input and Output Signals - includes television, audio, and data.
2. Digital Image Processing - includes color and luminance pixel and frame resolutions, compression and decompression algorithm processing for intra and inter-frame coding,

FIGURE 5-1 MODEL VIDEO TELECONFERENCING SYSTEM



as well as audio coding.

3. Codec Frame Format - includes basic characteristics of codec frame, bit assignments, error correction coding, encryption and decryption coding as well as multiplexing of audio, video and data signals.

4. Data Channel Frame - includes provisions required to interface with data transmission channels.

5.2 Identification of Parameters

In this section parameters of the four groups defined above are further described. The major emphasis is placed upon groups 2 and 3 because they involve the codec itself.

5.2.1 Input and Output Signals

Referring to Figure 5-1, the first parameter grouping is the input signal to the codec encoder and the output signals obtained from the codec decoder. These signals are the TV video and this study is primarily concerned with characteristics of the video signal.

In reviewing the codec vendor responses in Section 3, it is noticed that all codecs accept NTSC color or RS-170 monochrome TV signals as the video input. Thus, it seems clear that that RS170A standard for NTSC color video and the RS-170 standard for monochrome video should be specified as the standard for the input and output of video teleconferencing systems. This is a major consideration because presently the output signals from several codecs do not adhere strictly to these specifications as can best be determined from the data provided. The codec may also have capabilities to

process other video standards such as PAL signals, but it would not seem advisable at this time to also impose additional TV standards.

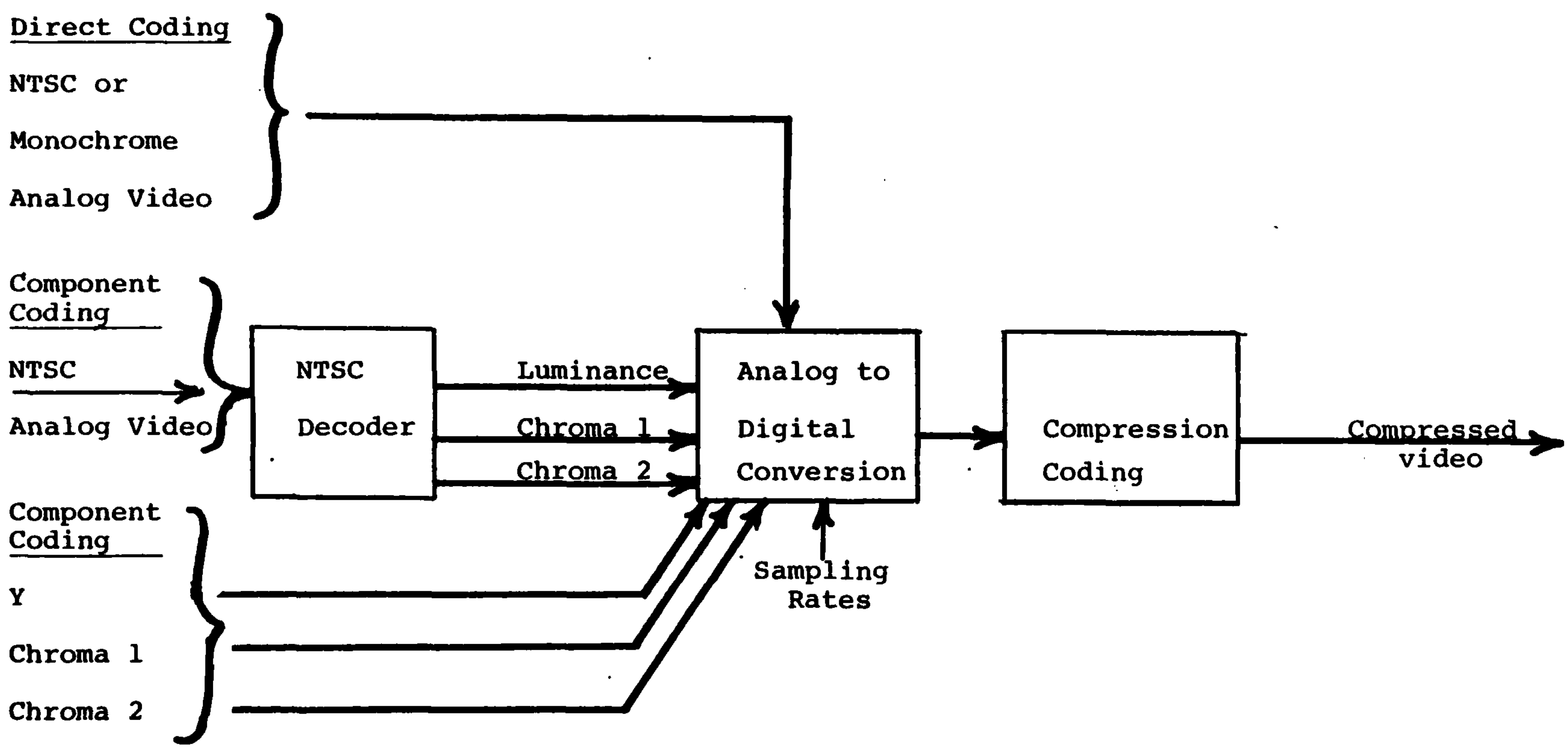
The quality of the output NTSC TV signal provided by the codec decoder is of concern in video teleconferencing systems. Table 4-6, Section 4, contains the performance ranges of the codecs for various video test signals that are commonly used in analog TV processing and transmission. These test signals do provide a measure of the overall performance of the codec and quality of the processed TV signal as evaluated by the user. This is particularly important since there are no digital measurements to evaluate these same parameters. SMPTE and others are performing analysis to determine theroretical limits for some of these video tests applied to digital TV codecs.

It seems necessary that minimum performance standards should be established for codecs used in video teleconferencing. However, considerable effort needs to be expended to determine acceptable performance criteria for these measurements.

5.2.2 Digital Image Processing

The Codec Processor-Encoder in Figure 5-1 performs most of the functions which determine the quality of the digital television image that is ultimately transmitted to the Codec Processor-Decoder. Figure 5-2 contains a generalized functional block diagram of the Codec Processor-Encoder which will be discussed in the following subsections.

Figure 5-2 Generalized Digital Image Processing Functions



5.2.2.1 NTSC Decoding

Compression techniques can be categorized in many ways. One of these is direct or component compression. Direct compression is performed directly on the input encoded color video signal. Monochrome video is by definition subject to direct compression. Component coding is performed on the color components of the input color video signal; (R,G,B), (Y,I,Q), (Y,R-Y,B-Y) or (Y,U,V), etc. R,G,B color video requires of necessity component compression. If the input video signal is in NTSC format and component compression is to be used, the video signal must first be decoded into one of the above component forms. These usually take the generalized form of Y, Chroma I and Chroma 2.

Two vendors indicate that they use some form of direct compression or no compression at all. Two indicated they used component compression and require color component inputs. The remainder are monochrome codecs or did not respond.

Figure 5-2 indicates the input block of a codec for these three types of input signal/compression arrangement.

a. Monochrome or encoded color video with direct compression.

b. Encoded color video with component compression.

c. Component video with component compression.

Although not shown or described explicitly below, it should be remembered that the decoding process from NTSC to color components can be performed in the digital domain after A-D conversion as well as in the analog domain as shown.

Therefore, the first function generally performed, Figure 5-2, is to demodulate and separate the NTSC TV signal into a luminance

and two chroma video signals when component coding is used instead of composite coding of the NTSC signal. The key parameter of interest in the video signals is their bandwith which affects the ultimate picture resolution.

5.2.2.2 Sampling and Digitizing

The next process involves the sampling and digitizing of the direct or component video signals which is usually performed in an analog-to-digital converter as shown in Figure 5-2. The important parameters associated with this function are:

1. Number of horizontal luminance and chroma pixels.
2. Number of vertical luminance and chroma pixels.
3. Encoding precision of each pixel.

Table 4-3 compares the values of the above parameters for the various codecs currently available commercially. These are depicted graphically in Figure 4-1. A possible set of resolution categories based on existing equipments and expected teleconferencing applications is depicted in Figure 4-2. Sampling and digitizing parameters are contained in Table 5-1.

The number of chroma horizontal and vertical pixels was not supplied by most of the vendors. Where PCM transmission is used with direct coding (CVI), the chroma resolution should be degraded by the system. Where direct coding is used with compression, the equivalent number of chroma pixels cannot be estimated without further data. GEC stipulated 256 chroma pixels horizontally. INT samples chroma of ¼ the luminance sampling rate which leads to the conclusion that

Table 5-1 Preliminary Values of Digital Image Parameters

1. Number of horizontal/vertical pixels; 684/484, 512 x 480, 256 x 240.
2. Luminance encoding precision - 8 bits per pixel.
3. Number of chroma component signals - 2.
4. Chroma encoding precision - 6/8 bits per pixel.

Note: In the case of direct coding, should it be used, the performance should be equivalent to that shown for component coding.

the chroma pixels should equal ¼ of the 640 luminance pixels or 160. The vendor responses together with these unverified estimates are listed in Table 5-2. Obviously, it is premature to suggest a set of possible values of these parameters based only on vendor responses.

5.2.2.3 Compression Algorithms

The next function generally involves the actual compressing of the digital video signals by intraframe coding techniques as shown in Figure 5-1. As noted previously in comparing vendor compression techniques in Section 4.6, none of the codecs commercially available are compatible or interoperable with each other. Although some vendors utilize similar coding, it is quite apparent that there is considerable movement among the vendors to incorporate modifications and options to improve resolution performance. One vendor (CVI) provides all the functions required of a codec except data compression. This is an option or can be implemented by the user.

Further, there does not appear to exist any uniformly accepted or standard set of images which can be utilized to compare codec parameters for video teleconferencing systems and applications. Therefore, it is difficult at this time to specify that a particular coding technique or codec is "best" and should be adopted as a standard. Because codecs are often being upgraded by the rapidly growing compression technology and because image standards for teleconferencing need to be developed, a series of steps leading toward the development of a codec algorithm standard is presented

Table 5-2 Estimates of Chroma Pixels

Parameter, Specification or Performance	CVI	NEC	RRI	MAR	INT	GEC	GRI	ESI
Luminance or Composite Sampling Rate	10 MHZ	10.8 MHZ	5 MHZ	10.33 MHZ	12 MHZ	9 MHZ	N/A	15.75 KHZ
Chroma Horizontal Sampling Rate								
a. Chroma 1	Direct	Direct	Mono	Direct	3 MHZ	4.5 MHZ*3	Mono	Mono
b. Chroma 2	Direct	Direct	Mono	Direct	3 MHZ	4.5 MHZ*3	Mono	Mono
Reported or Estimated Chroma Horizontal Pixels								
a. Chroma 1	*PCM	*1	Mono	*1	160*3	256	Mono	Mono
b. Chroma 2	*PCM	*1	Mono	*1	160*3	256	Mono	Mono
Chroma Precision								
a. Chroma 1	*(PCM)	*1	Mono	*2	6%	N/A	Mono	Mono
b. Chroma 2	*(PCM)	*1	Mono	*2	6%	N/A	Mono	Mono

Notes

*(PCM) - 8-bit PCM transmission is used. Chroma performance of output should parallel input.

*1 - Not enough data provided to perform a reportable analysis.

*2 - Vendor states 8-bit chroma precision. Since direct coding is used, this is interpreted as 8-bit precision referred to p-p composite video.

*3 - Estimate

Since much of this data is an interpretation of vendor responses to the questionnaire, the reader is referred to Section 3 to draw independent conclusions.

in Section 6.0 of this report.

5.2.3 Codec Frame Format

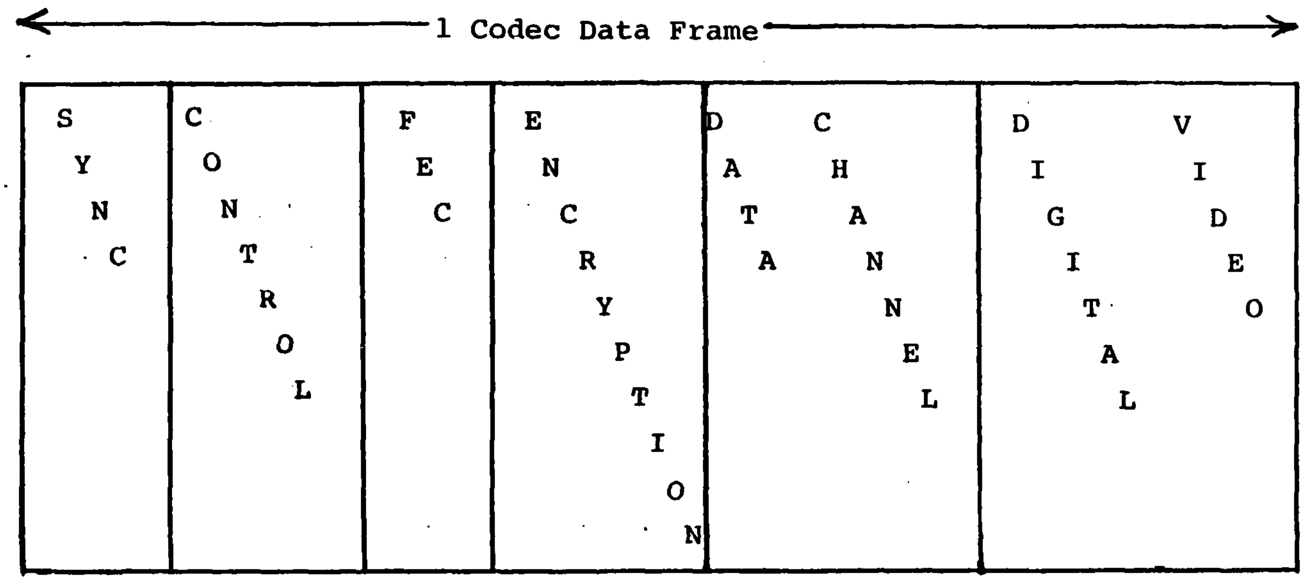
Figure 5-3 depicts a generalized codec frame format. It shows how a codec frame could be partitioned in order to transmit information, data, and control bits as well as providing for data channel framing bits and bits for data link error correction. In determining an overall compression ratio for a codec, all bits must be used in the calculation; thus, bits other than digital video bits tend to decrease the codec compression ratio and increase the transmission time for the digital TV image at a given bit rate.

5.2.3.1 Frame Size and Bit Assignment

In Section 4.4.3, the codec resolution in pixels is specified. This data together with the compression ratios stated define the frame size in terms of tatal bits (open to interpretation). No information was provided in terms of overhead bits of any type. As a result, the total frame size cannot be determined; neither can the bit assignments be specified. Considerably more data is needed from the vendor.

It would seem reasonable that codecs would be simpler to interoperate if a common frame format identical with the primary data channel frame format were chosen as a standard. As long as channels are used whose inputs can be unformatted, this assumption appears valid. Also required is the ability of the codec to adjust to the data rate.

Figure 5-3 Generalized Codec Frame Format



Because technology improvements in codecs are continuing, it appears that adopting one standard frame format such as T1 may be too restrictive. This is an area which needs further study. In the meantime, it is recommended that wherever possible codec frame formats be used which are compatible with standard or commonly used channel formats at the various bit rates of concern.

5.2.3.2 Audio and Data Multiplexing

Inclusion of audio and user data signals in the codec frame bit allotment is an interesting problem. Audio transmission requires that bits be available to produce a continuous reconstructed audio signal. In addition, some relation to real time must be retained particularly if two way conversations are to be conducted. The half second delays in satellite telephone circuits are generally considered very annoying. Assuming ¼ second delay is tolerable, packet of audio must occur at least at ¼ second intervals or more frequently. This then also defines the size of the audio packet. None of the vendors provided audio multiplex data. Data is not restricted in this way and, therefore, can be assigned specific slots in the data stream. For interoperability requirements, once these problems are resolved, the audio codecs must use compatible compression algorithms and bit rates. Similarly, input data ports to the codec must use compatible data rates.

5.2.3.3 Error Correction

A form of forward error correction coding has been incorporated in only one of the codecs to reduce the susceptibility to data link errors which allows the codec to operate on unusually poor trans-

mission channels at the expense of increased transmission time. Additional bits must be added to the codec data frame to provide the correction capability. A description of error correction coding by the vendor was not provided.

For interoperability of codecs, if FEC is used, it must be standardized. Because a "standard" data frame has not been established yet, then a standard FEC cannot be specified either. However, it would appear that the selection of a FEC would not be difficult to accomplish, if it is found to be needed. Some investigation is first required to determine the performance of codecs over channels with conventional BER.

5.2.3.4 Encryption

None of the vendors indicated that their codecs incorporated encryption either as a standard or an optional function. One vendor indicated compatibility with DoD encryption devices. In the motion codecs discussed in a previous report, encryption coding was provided in several codecs. Although the functional utilization differed among the codecs, the Data Encryption Standard (DES) is used by three vendors. Thus, it seems reasonable to recommend the DES algorithm as a standard pending further consideration.

5.2.4 Data Channel Format

Another group of parameters of interest in video teleconferencing systems is associated with the format of the data channel used to transmit the codec data. None of the vendors provided

explicit information about the data format or the structure of the data stream. Data rates are defined in Section 4.8.1; however, transmission channels are available which will accept this data totally unformatted. The equipments within the data channel may format the data to prepare it for inclusion into a channel compatible with the digital hierarchy (e.g. mux, channel bank, etc.).

It would seem reasonable that data rates which either can be accepted by formatting devices or which already are formatted to specifications of members of the digital hierarchy are good candidates for standardization for freeze frame codecs. In this sense, the specific data rate is critical as are the frequency tolerance, frame scheme, word sync, coding, etc.

5.2.5 Transmission Channel Interface

The last group of parameters in the model video teleconferencing system are concerned with the transmission channel hierarchy and its interfaces. As previously discussed, the parameters associated with the transmission channel may be identical or an integral part of the data channel format parameters.

In general, the lower data rates, 64KB and below, do not need specific formatting bits. This data is added (if required) when that signal is multiplexed into one of the digital hierarchy signals. This covers the majority of cases. There may be some advantage to formatting the higher data rates unless they are to be multiplexed to TI rates.

Because of the wide variety of applications, it may be necessary for codec vendors to supply several different data channel and transmission channel interface standards in order to compete in the

market place. Interoperability between motion codecs could probably not occur if different data and transmission channel formats are used. Therefore, in connection with the study mentioned above, aggressive coordination efforts with the common carriers should be undertaken to attempt to influence the transmission and data formats.

5.3 Candidate Parameters for Standardization

Based upon the comparisons of parameters in Section 3 and 4 and discussions contained in earlier parts of this section, a set of candidate parameters for digital video codecs has been identified and quantified where possible as listed in Table 5-3. This list of codec parameters covers the input video signals, the specification of the digitized image, the compression algorithm, codec framing format, and compatible digital interfaces for a data channel.

Standards could be proposed for adoption for some parameters immediately as little controversy exists or common acceptance has already been made. Some suggested parameter ranges are listed especially in the specification for the basic digitized image. However, additional effort should be expended in studies, analyses, measurements, testing, standard image generation and evaluations to help further establish suitable values and ranges of codec parameters for video teleconferencing. Interoperability of codecs can be achieved if appropriate standards are developed and adopted for the parameters contained in Table 5-3.

Table 5-3 CANDIDATE PARAMETERS FOR STANDARDIZATION

Parameter Category	Parameter	Recommendations		
		Suggested Standard	Suggested Parameter Range	Further Efforts/Comments
A. Input/Output Signals	1. Color television signal, input and output. Monochrome television signal, input and output.	NTSC, RS170A RS170		All video inputs including monochrome TV, computer graphics, VTR's would be required to generate RS170A signal.
	2. Audio signal input and output characteristics			Study needed to determine advisability and scheme of multiplexing audio and video data and audio quality requirements for video teleconferencing.
	3. User data input and output ports	RS 232 RS 449		These standards are universally used and are specified by some codec vendors. The effect on image transmission time may be substantial. Study is needed to select devices and data rates which do not tax transmission time when multiplexed with video data. Higher data rates may share channel on an alternating basis.
	4. Output NTSC performance measurements including video frequency response, signal-to-quantizing noise ratio, luminance-chrominance gain and delay inequalities, differential gain and phase, and waveform distortions for short time, line time, field time.			Standard measurement program needed to establish performance requirements for teleconferencing, and specifications should take into account the digital environment.

Table 5-3 (Continued)

Parameter Category	Parameter	Recommendations		
		Suggested Standard	Suggested Parameter Range	Further Efforts/Comments
B. Digital Image Processing	5. TV signal coding.	Component	One luminance and two chroma video signals.	Component coding offers more flexibility in compression technology than composite coding.
	6. Horizontal/vertical luminance pixels		a. 684 x 480 b. 512 x 480 c. 256 x 240	Measurements and testing with standard images and sequences are needed to evaluate further pixel and precision requirements for teleconferencing
	7. Luminance encoding precision		8 bits per pixel	
	8. Horizontal chroma pixels		75-200	
	9. Vertical chroma pixels		240-480	
	10. Chroma encoding precision		6-8 bits per pixel	
	11. Compression algorithm parameters including resolution, color fidelity, geometric distortions, artifacts.			Performance measurements and subjective testing using standard images should be conducted on competing codecs at various bit rates.

Table 5-3 (Continued)

Parameter Category	Parameter	Recommendations		
		Suggested Standard	Suggested Parameter Range	Further Efforts/Comments
C. Codec Frame Format	12. Frame size and bit assignment		Resolution has previously been defined (Section B). This together with encoding precision defines the frame size except for synchronization requirements. It is suggested that luminance be transmitted first, followed by the chroma signal. Sync remains to be defined.	
	13. Audio and data coding parameters including sampling rate, precision, compression, algorithm, bit rate.			These parameters are intrinsically related to channel transmission rate and picture transmission time. Existing codecs use different coding techniques and bit rates. Measurements and subjective testing should be conducted to determine teleconferencing requirements.
	14. Error correction coding parameters including code type, block size, correction bits.			Study and analysis of requirements for teleconferencing need to be conducted. Susceptibility of codec compression algorithm to bit errors and expected BER of communication channels should be considered. May be implemented as a modem function.

Table 5-3 (Continued)

Parameter Category	Parameter	Recommendations		
		Suggested Standard	Suggested Parameter Range	Further Efforts/Comments
	15. Encryption coding parameters including block size, sync and frame bit in the clear, separate coding for information bits.	DES		Three motion codecs use the DES encryption algorithm. A study is needed to determine a) if this technique is applicable to freeze frame codecs and if all bits should be encrypted (may cause interface problems with data channel format requirements), only information bits, b) size of encryption block, and c) separate coding of video and audio.
D. Data Channel Frame	16. Bit Rate		Up to 500KBS at selected intervals such as 1.2, 2.4, 4.8, 9.6, 19.2, 56, 64 & 256 KBS	Frame transmission time and picture resolution using standard hierarchy data channels will probably determine specific channels to be used.

SECTION 6.0

RECOMMENDED EFFORTS TOWARD PROPOSING CODEC STANDARDS

6.0 Recommended Efforts Toward Proposing Codec Standards

6.1 Discussion

Several recommendations are presented in this section for studies and tests leading toward the development and proposal of standards for the parameters and specifications of digital freeze frame video teleconferencing systems for Federal government agencies in order to provide interoperability. Within this Final Report, recommendations have been listed based upon comparisons of various codec parameters currently in existence. These recommendations are included within the efforts proposed herein. One of the most important aspects of the continuing codec study effort is the coordination with organizations who are working on standards for digital television systems, equipments and transmission including SMPTE, CCITT, ITCA, and IEEE.

6.2 Development of Standard Video Materials

Many different types of codecs have been developed and installed in various teleconferencing systems as previously described. Vendor claims of performance are often clouded with special conditions and are based on TV images which are not necessarily typical of conferencing and do not realistically test the quality of the codec. Thus, there is a need to develop a set of standard single-frame TV pictures and sequences of TV frames for objective and comparative evaluation of both motion and freeze-frame codecs.

In the development of the single-frame pictures for testing codecs the following efforts are necessary:

a. Selection of test images.

b. Specifying the digital coding standard for converting to digital format.

c. Selecting the digital recording medium.

d. Preparing the standard master digital tape.

e. Specifying the digital to analog process for generating test analog images from the master digital tape.

6.3 Continuing Freeze Frame Codec Study and Analysis

This Final Report describes the initial work of obtaining codec information and making comparisons of various parameters and characteristics. It has been mentioned several times that the digital television compression technology is progressing very rapidly in that codecs have been developed and fielded by eight companies in the United States and Great Britain. Further, many of these companies have planned enhancements and modifications to their codecs to improve performance or reduce costs. It is thus recommended that the initial study effort be continued and expanded as described below in order to continue the development of recommendations for standard parameters and characteristics.

6.3.1 Update Codec Comparisons

The information on codecs should be updated and expanded to include new characteristics and enhancements, but more so to fill in missing data and clarify some of the information provided. A revised questionnaire should be prepared and sent to codec manufacturers. Subjective comparative evaluations of installed systems

and their user applications should continue.

Specific examples of data to be provided or clarified include the following:

a. Vendor's definition of pixel or resolution, together with specifications for his equipment (luminance or chrominance).

b. Precise information on sampling format: samples per active line, number of vertical samples during active time, number of samples occurring in blanking, field or frame sampling.

c. True reproduced luminance and chrominance encoding precision, etc.

6.3.2 Vendor Contact

It will be very desirable to discuss the data received directly with the vendors to clarify responses received as a result of the revised questionnaire. It is anticipated that this will be an essential follow-up to the questionnaire to resolve any remaining ambiguities in the data provided.

6.3.3 Codec Evaluation

It is essential that the performance of the codecs discussed be throughly evaluated by qualified personnel before draft recommendations are made for codec standardization. This will further eliminate any ambiguities in the semantics of specifications and the corresponding data by applying standardized tests to independently determine the data on a truly common objective basis as far as

possible. Section 6.4 and 6.5 outline the process for evaluation.

6.3.4 Investigate Communication Carriers

The previous study of common carriers should be expanded to include a detailed questionnaire about video teleconferencing links. There are several new resale common carriers emerging and offering digital video teleconferencing communication links and networks. Among the information to be determined is the following:

a. Digital hierarchy and multiple bit rates
b. Interface requirements
c. Framing format requirements
d. Costs and availability
e. Bit error rates
f. Multiple nodes and networking for teleconferencing and control
g. Switched and dedicated links and control.

6.3.5 Coordination with Standards Organizations

This Final Report has briefly mentioned the efforts by organizations such as CCITT, CCIR, and SMPTE which have active study and working groups studying and developing recommendations for various standards and characteristics of digital television equipments and transmission systems. Other organizations include IEEE, EIA, and ITCA in the United States. Outside the United States are the following organizations involved in digital TV:

EBU-European Broadcasting Union
ITEJ-Institute of Television Engineers of Japan
IEC-International Electrotechnical Commission
ISO-International Organization for Standardization

Because of the rapid development of digital TV equipments, codecs, and digital transmission data channels and hierarchies, it is recommended that active coordination be continued with those standards organizations which are working toward national and international standards for digital video teleconferencing and specifically Freeze Frame codecs. This participation will expedite the timely disemination of proposed standards which could bear upon the effort to establish U.S. Federal Standards for digital video teleconferencing.

6.4 Development of Standard Measurement Techniques for Codec Parameters

During the comparison of codecs in this report, it was very apparent that the different manufacturers of the codecs use different techniques and procedures for measuring the many codec parameters and characteristics. There are established procedures for measuring some of the analog TV performance tests using standard video test signals.

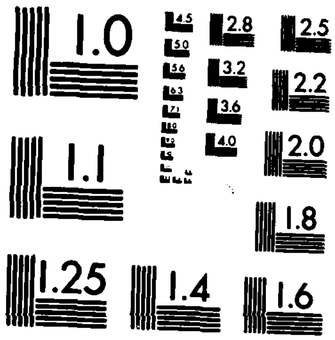
However, there are many characteristics of codecs for which no standard techniques or measurement criteria appear to exist. Therefore, it is recommended that a study be initiated to undertake the establishment of standard techniques and procedures for testing and evaluating motion codecs.

6.5 Perform Codec Testing and Evaluation

A most important recommendation in determining the comparative evaluation of codecs should be independent testing of the codecs

AD-A141 278 STUDY OF POTENTIAL STANDARDIZATION OF DIGITAL FREEZE FRAME VIDEO CODECS(U) DELTA INFORMATION SYSTEMS INC JENKINTOWN PA JAN 84 NCS-TIB-84-3 DCA100-83-C-0047 2/2

UNCLASSIFIED F/G 17/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

to verify performance. In this way, recommendations for codec parameters, specifications, and characteristics can be evaluated and assessed as candidates for standardization.

The comprehensive testing using standard video materials (Section 6.2) and applying standard measurement techniques (Section 6.4) should provide accurate information for the development of recommendations for standardizing codec parameters.

6.6 Draft Recommendation for Freeze Frame Codec Standard

It is recommended that the results of all the other efforts outlined in Section 6 be used to prepare inputs in conjunction with other cooperating United States organizations for a recommended draft Federal Standard for video Freeze Frame codecs. After adoption, Freeze Frame codecs and systems built and tested to the standard could be utilized by various government agencies and be assured of compatibility and interoperability.

6.7 Establish Video Codec Test Bed

As shown in this report, there are a large number of vendors manufacturing Freeze Frame codecs and several additional vendors are developing products. Previous studies by the NCS show that motion codec technology is rapidly developing. It is recommended that a test bed be established for the continuing testing and evaluation of Freeze Frame codecs and motion codecs for teleconferencing applications in order to provide guidance to Federal agencies concerning the technical evaluation of modified and new codecs which are emerging in the marketplace.

The test bed, utilizing the previously developed standard

images and video sequences and standard video performance measurement parameters, would allow the evaluation of codecs to be conducted and compared with proposed or adopted Federal codec standards. Also, vendors could utilize the services of the test bed to determine the performance of their equipments relative to standard images and to the proposed Federal Codec Standards.

APPENDICIES

APPENDIX A

VENDOR LETTER AND

INSTRUCTIONS FOR QUESTIONNAIRE

APPENDIX A

DELTA INFORMATION SYSTEMS, INC.
310 COTTMAN STREET JENKINTOWN PA 19046
(215) 572-5640

Subject: Freeze Frame Codec Vendor Questionnaire

Reference: (1) Contract No. DCA100-83-C-0047
(2) Delta Information System previous letter, July 1983

Dear Mr. Carr:

In my previous letter to you, Ref. 2, I indicated that the National Communications System (NCS) under contract, Ref 1, to Delta Information Systems (DIS) is conducting a study to determine the feasibility of establishing Federal Standards for digital freeze frame/still frame/slow scan television codecs.

Because of your involvement with the DoD in the design and implementation of a digital freeze frame system, your participation in this study is solicited. Enclosed you will find a questionnaire to complete which should provide technical information for this study.

It is emphasized that no proprietary data be included as I expect the NCS will distribute the subsequent study report within various government agencies and possibly outside the government. Again, the NCS technical monitor for this program is Mr. D. Bodson, Area Code 202-692-2124. It is hoped that you can return the completed questionnaire by October 11, 1983.

APPENDIX B

OUTLINE OF

FREEZE FRAME CODEC VENDOR

QUESTIONNAIRE

OUTLINE OF

FREEZE FRAME CODEC VENDOR QUESTIONNAIRE

PART 1 Product Nomenclature and General Description

1. Vendor Identification
2. Codec Identification
3. Pricing
4. Product Life
5. Warrantees
6. Service, Maintenance, Repairs, Spares, Training

PART 2 Technical Specifications Input and Output Signals

1. Video Input Signals
2. Video Output Signals
3. Digital Output and Input Signals

PART 3 Technical Specifications

1. Video Performance
2. Bit Rate Performance
3. Compression Technique

PART 4 Physical Description and Specifications

1. Mechanical Dimensions
2. Environmental Operation
3. EMI/EMC
4. Connectors

PART 5 Other Data about Product

1. Status/Alarms
2. Bite
3. Front Panel/Operator Controls
4. Encryption/Scrambling
5. Documentation/Manuals
6. Brochures/Technical Notes

APPENDIX C

ADDENDA TO TABLES

APPENDIX C

ADDENDA TO TABLES

1. ADDENDUM CVI - 1

MODEL 285/285C USERS LIST

1. Defense Supply Agency - Washington
   For:
   DCOA (FA) DACA - FAP - I
   Indianapolis, Indiana 46249
   Contact: William R. (Rudy) Reilly
   Data Communications Specialist
   317/542-3609

2. EG&G, Incorporated
   Las Vegas Area Operations
   316 East Atlas Circle
   North Las Vegas, Nevada 89030
   Contact: Chuck Gladden
   702/739-0584

3. Phillips Petroleum Company
   Bartlesville, Oklahoma 74004
   Contact: Don Ballew
   918/661-8199

September '83

2. ADDENDUM NEC - 1

TVS USER LIST

Interand Corporation
666 N. Lake Shore Drive
Chicago, Illinois 60611

Contact: Val Vitter
943-1200

American Satellite Company
1801 Research Blvd.
Rockville, Maryland 20850

Contact: Donna King
(301) 251-8420

Bruce Badger
(301) 251-8300

Ed Yarbrough
(301) 251-8300

Mr. Mehta
(301) 251-8300

Satellite Business Systems
8283 Greensboro Drive
McLean, Virginia 22102

Contact: Mr. A. Fabris
(703) 442-5000

Satellite Business Systems
200 S. Wacker Drive
Chicago, Il. 60606

Contact: Mr. Tim Lee

Satellite Business Systems
Tyco Industrial Park
8504 Tyco Road, Bldg. 3
Vienna, VA. 22180

Ma Com
7100 W. Camino Real
Boca Raton, FL. 33433

Contact: Kay Maxey
(305) 393-6600

Ma Com
1350 Picard Drive
Rockville, Maryland 20850

Contact: Mr. Cacciamini

Standard Oil Company
200 E. Randolph
Chicago, IL. 60601

Contact: John Vogt
(312) 856-5011

Proctor & Gamble Company
301 E. 6th Street
Cincinnati, Ohio 45201

Contact: Susan Velander
Bev Bach
(513) 562-5717

Proctor & Gamble Company
State Route 1529
Greenville, N.C. 27834

Contact: Scott Carter
(919) 752-1100 Ext. 490

Comsat General Corporation
22300 Comsat Drive
Clarksburg, Maryland 20871

Contact: Dave Quinones
(301) 428-5097

U. S. Department of Energy
P. O. Box E
Oak Ridge, TN. 37830

Contact: Gerry Mendoza
(615) 574-7719

Exxon Research & Engineering
4500 Bayway Drive
Inside Exxon Refinery
Baytown, TX. 77520

Contact: Carolyn Julian
(713) 425-5021

Westinghouse
Sturtenvant Division
Damon Street
Boston, MA. 02136

Contact: Charles Tillett
(617) 929-1409

G T E Labs.
40 Silvan Road
Waltham, Mass. 02254

Contact: Mr. Swank
(617) 466-2379

Paul Christenson
(617) 466-2364

Boeing Computer Service
674 Industrial Drive
Building 12
Tukwila, WA. 98188

Contact: Dale Fisher
(206) 575-7349
Frank McLean

NASA
Goddard Space Flight Center
Greenbelt, Maryland 20771

Contact: Henry Wagner
(301) 344-5442

Ford Motor Company
Atlanta, GA.

Contact: Louis Dunken
(404) 424-5687

I B M
600 Mamaroneck Ave.
Harrison, N. Y.

I B M
Albany, N.Y.

Contact: Meryl Gutridge
(914) 383-6773

Hercules, Inc.
Highway 41 North
Terre Haute Plant
Terra Haute, Ind. 47805

Contact: Judy Monday
(812) 466-4277

Hercules, Inc.
West 7th Street
P. O. Box 1937
Hattiesburg, MS. 39401

Contact: Z. A. Parish
(601) 545-3450

WARRANTY

NEC America, Inc. (hereinafter "NEC") warrants that this Product is free from defective material and workmanship and, subject to the conditions hereinbelow set forth, agrees:

to repair or replace this Product, or any part thereof, which proves defective by reason of improper workmanship or materials (i) for a period of (3)three months from the date of original purchase, without charge for parts or labor and (ii) for a period of one (6) monthsfrom the date of original purchase, without charge for parts but with labor charges at then current rates.

This warranty is limited to the original purchaser of the Product.

This warranty shall not be effective unless the Product was purchased from NEC, and NEC Dealer or other person authorized by NEC to sell Products.

The Product shall be shipped, freight prepaid, or delivered to a facility authorized by NEC to render the services provided hereunder in either the original package or a similar package affording an equal degree of protection.

The Product shall not have been previously altered, repaired or serviced by anyone other than a service facility authorized by NEC to render such service; the serial number on the Product shall have not been altered or removed; the Product shall not have been subject to accident, misuse or operation contrary to the instructions contained in the accompanying manual.

NEC SHALL NOT BE LIABLE FOR DIRECT, INDIRECT, INCIDENTAL, CONSEQUENTIAL, OR OTHER TYPES OF DAMAGES RESULTING FROM THE USE OF ANY NEC PRODUCTS OTHER THAN THE LIABILITY STATED ABOVE. THESE WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

PRODUCT REPAIR

If an NEC product is found to have a problem, the customer should first call NEC. A significant number of problems can be solved very quickly via the telephone. Should the problem warrant further repair assistance, the customer has basically two (2) options in the repair of equipment by NEC. They are as follows:

Warranty Service

1. The product involved may be shipped (freight prepaid) to NEC for repair. Before shipping equipment back to NEC, we require the customer to contact the Engineering Department to receive a return authorization number. In most cases, circuit cards are available on a loan basis to the customer during the repair of customer owned cards. The loan of any items is an option of NEC's and is subject to availability. To prevent any charges, all loaned items shall be immediately returned to NEC upon receipt of repaired items or at the request of NEC.

2. A Field Service Engineer may be dispatched to the customer location to facilitate repair. The visit must be scheduled through the NEC Engineering Department. A Purchase Order must be given at the time of scheduling to cover the cost of travel and expenses incurred for the repair visit, however, parts and labor costs will not be charged when the product is in warranty.

Out Of Warranty Service

1. The product may be shipped (freight prepaid) to NEC for repair. Prior to shipment, the customer shall contact the NEC Engineering Department; (1) to issue a purchase order for the repair of the defective product and (2) to receive a return authorization number for the returned product. In most cases, circuit cards are available on a loan basis to the customer during the repair of customer owned cards. The loan of any items is an option of NEC's and is subject to availability. There is a one time only loan charge of $100.00 per incident regardless of the number of items loaned. To prevent any additional charges, all loaned items shall be immediately returned to NEC upon receipt of repaired items or at the request of NEC.

2. The customer may request a Field Service Engineer to repair the problem at the equipment site. Such a visit would have to be scheduled by the NEC Engineering Department. A Purchase Order must be given at the time of scheduling to cover the cost of labor, travel and expenses. Labor charges will be at the current hourly rates.

4. ADDENDUM RRI-1

2.g. Robot sells all of their scan converters through a system of dealers. We make no direct sales. Dealers are jealous of their customers, and customers are typically secretive, therefore we have very little direct knowledge of customers and their names. We can provide company names and the dealer who sold them the equipment.

Health Care Financing Administration - Tom Volk, Future View (Dealer)
Phone: (202) 393-1970

G.E., Binghampton, N. Y. - Bob Romano, Univisions Video Systems (Dealer)
Phone: (315) 437-0301

We have enclosed a major user's list and may be able to provide additional information on specific entries upon request.

4.d. Robot has manufactered custom configurations (VAT 2 memory terminals, 56K bit digital transmission sets). We have a limited custom capability and are not in the custom unit business.

6. ADDENDUM RRI - 3

6.p. Robot slow scan converters are sold as a part of a system by Robot system house/dealers. The dealer is first responsible for system maintenance and Robot does all necessary repairs to returned equipment here at the factory.

ROBOT RESEARCH INC.
7591 Convoy Court
San Diego, California 92111
(619) 279-9430

Response to Part 3.

Our slow scan converters (codecs if you will) are designed for narrowband operation. We build our own modems which send pixels at a rate of 1969 pixels/second. Grey scale information is FM modulated on the carrier for an effective bit rate of 11,814 (1969 X 6) bits per second. Pixel value accuracy is very low, however the relative difference in brightness between pixels is maintained quite well and therefore perceived image quality is good.

It is clear that for secure encryption, a digital transmission system is necessary. For a signal between 1200 and 2300Hz a FSK or PCM digital modem would result in a much slower transmission. We have been told by our customers that time is of the essence and have opted for FM for reliability. AM modulation would cut our transmission times in half, but sacrifice noise immunity. This would mean lower reliability in long distance and intercontinental calls.

We are developing a color system for narrowband applications that will send component encoded color pictures at times comparable to the current monochrome systems. This modulation system is also black and white compatible, that is to say, all Robot units using this system will be able to transmit and receive from each other whether color or monochrome. Component encoding also means that in international use, images can be exchanged between different standard video systems (example PAL to NTSC).

Due to time requirements, the number of pixels and lines will remain similar to present units.

7. ADDENDUM GEC J-1

FRAME STORE - Max Capacity - 1M x 8 bits

Divided into 16 modules of 256 x 256 x 8 bits which can be configured by the user to allow storage of several pictures of different resolutions.

GRAPHICS - The 8-bit wide frame store can be split into a 7+1 bit store. The single bit plane can be used as a graphics overlay. Data can be written into the graphics plane using a light pen or graphics tablet.

The gray level of the graphics plane can be altered from the keypad, or switched off for later viewing.

CURSORS - Two cursors are available on the screen. One controlled locally, the second by the remote user. The cursors can be controlled by cursor keys on the keypad or alternatively by a light pen or graphics tablet.

INSERTS - User defined rectangular area positioned anywhere on the screen. Transmisison dedicated to that area thereby increasing the update time.

ADDITIONAL FEATURES - Menu - A menu driven set-up procedure is used in conjunction with keypad giving user selection of the following:

Frame Store Partitioning - number and resolution of pictures.

Full Frame/Inserts/Graphics

Transmisison coding-PCM/DPCM/VLC

Error treatment - Retransmits/Conceal

Update Direction - Horizontal/Vertical

Operators assigned to Graphics and Cursor control

Camera/Input selection

The set-up parameters are transmitted to remote user to prevent incompatible operation.

A default mode can be requested by customer

Prompt - A prompt area is positioned at bottom of picture providing information on status and mode of operation.

Operation - The keypad has a number of special function keys to permit user easy control of picture transfer.

- Picture transfer requested from receiver or transmitter.
- Continuous/single frame transfer
- Hold on any picture to prevent it being overwritten
- Capture of a number of pictures before transmitting

8. ADDENDUM GEC J-2

EFFECT OF TRANSMISSION ERRORS- Errors in the received data should be identified by the checkword. With retransmisison of affected video no degradation should be observed in picture quality, only an increase in transmission time.

With concealment selected, the picture is degraded depending on error rate and distribution.

No loss of sync should occur. The retransmission mechanism will monopolise data link during large error rates.

The concealment mechanism will stop if ten or more adjacent lines are lost. The prevents excessive grabbing of CPU time interpolating lines which give little information to the picture.

ERROR TREATMENT - Data blocks are transmitted with sequence numbers and identification codes so that the receiver is able to ascertain which blocks have been corrupted and identify them as control, video, etc. Corrupted blocks are detected by use of a CRC contained within the block. The transmitter will automatically retransmit control, graphics, user data, alarm

blocks if not acknowledged.

Video blocks can be concealed by interpolation of retransmitted. This is selected by the user.

END

FILMED

DTIC